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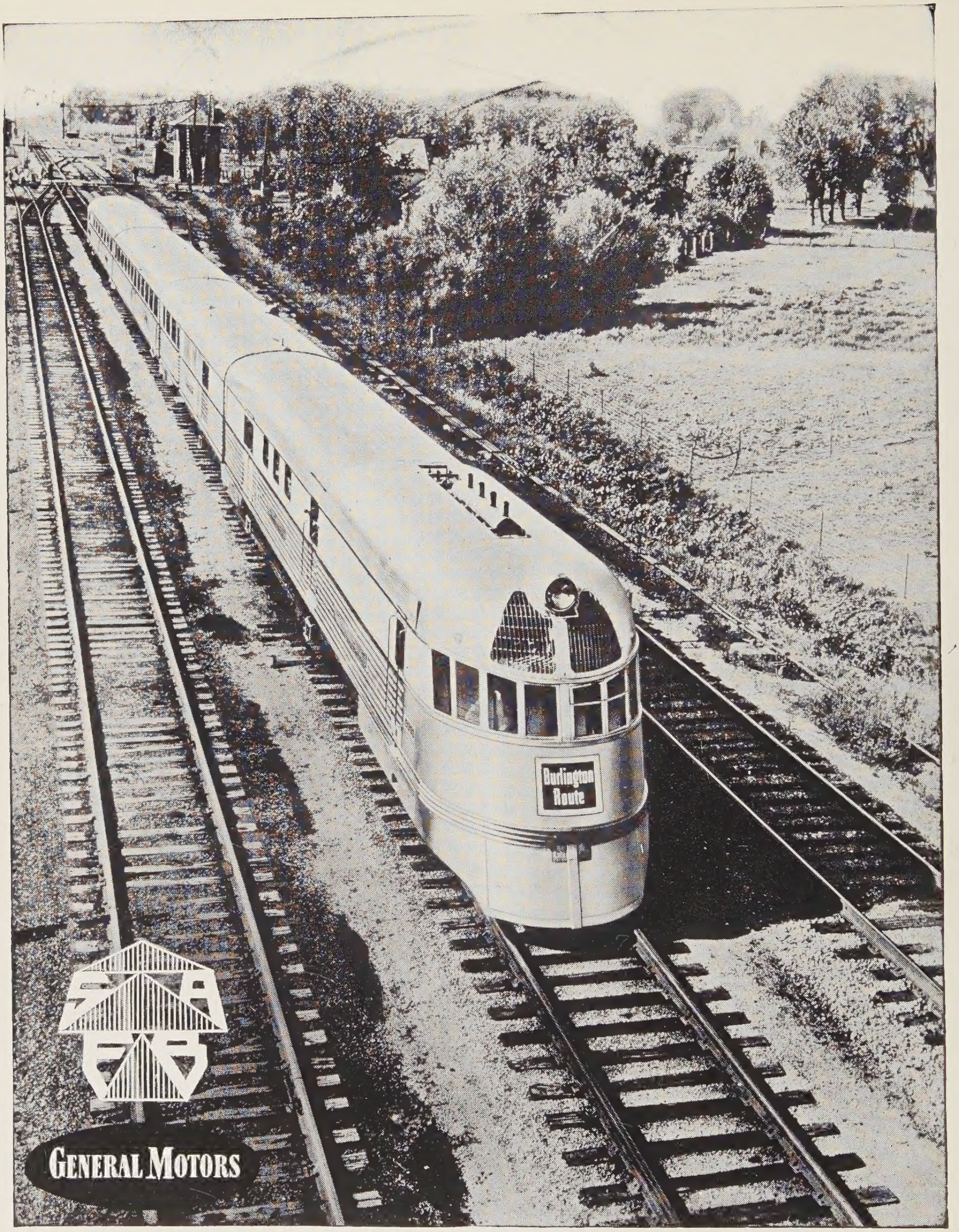
Monthly Bulletin of the International Railway Congress Association

(English Edition)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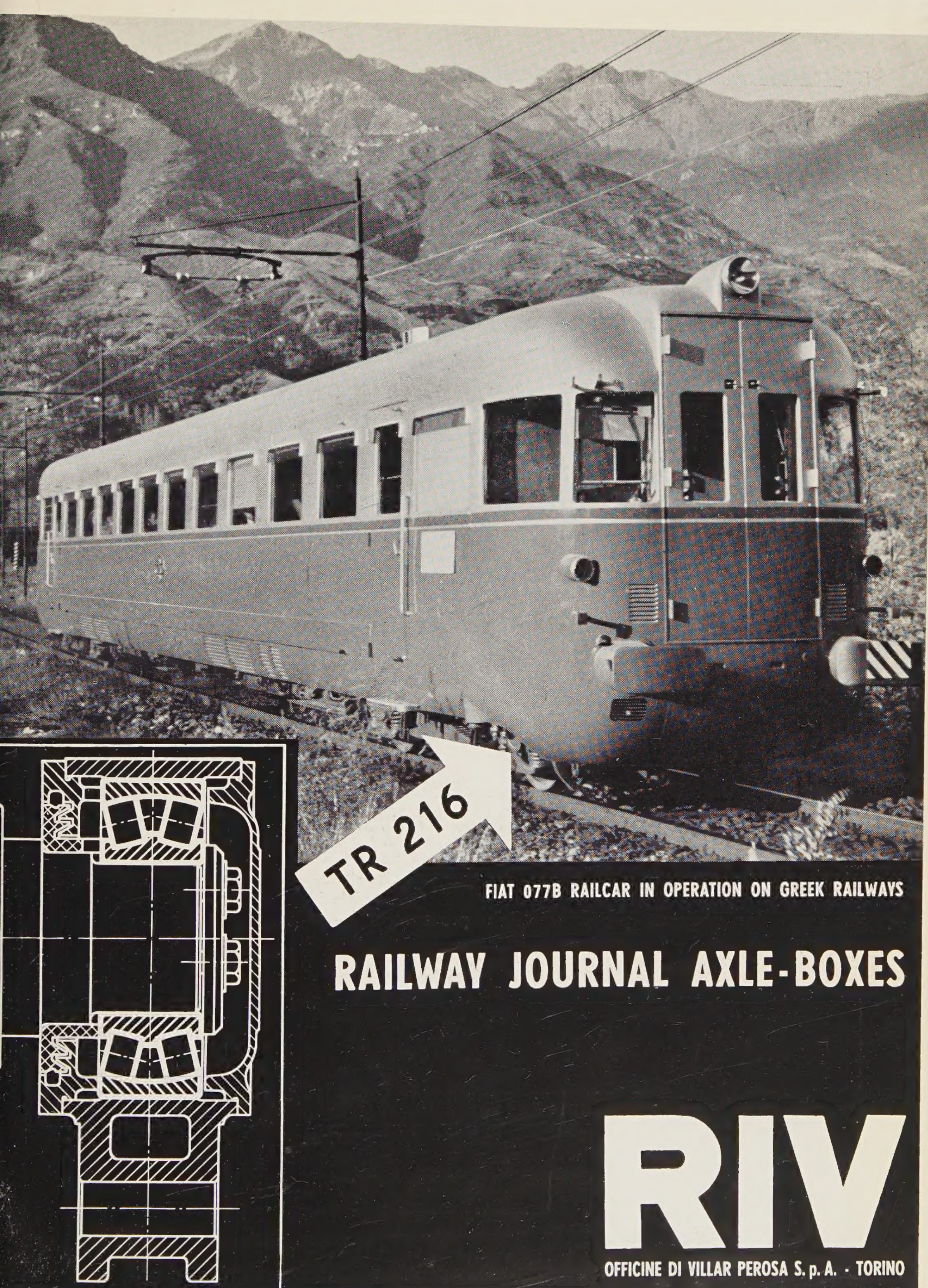
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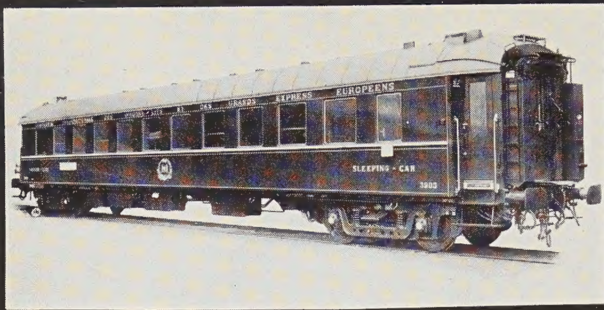

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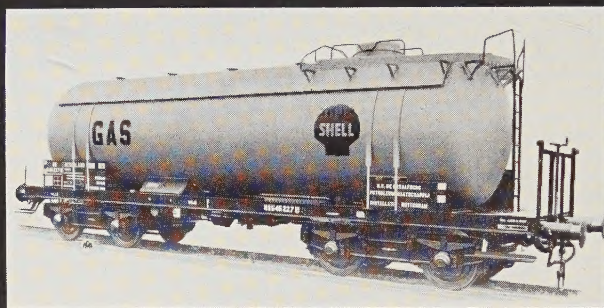

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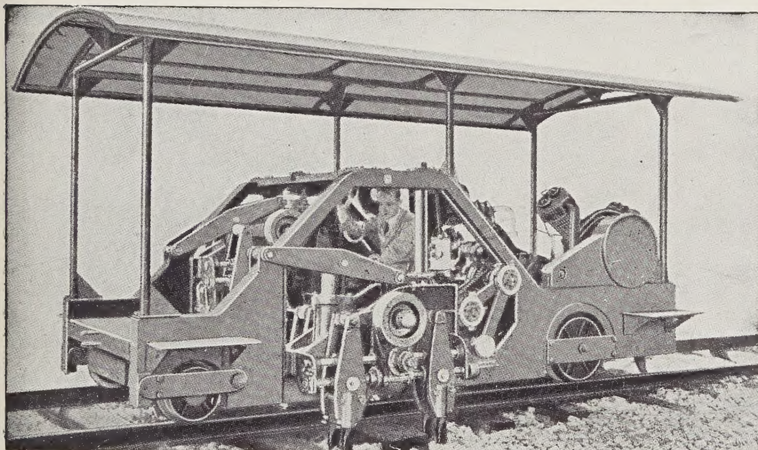

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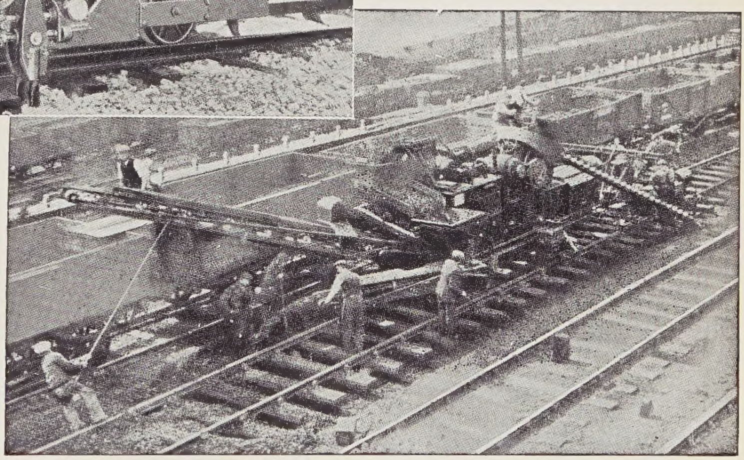

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CONTENTS OF THE NUMBER FOR JULY 1951.

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OF THE

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CONTENTS OF THE NUMBER FOR JULY 1951.

CONTENTS.	Page.

CONTENTS *(continued)*.	Page.

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Vol. XXVIII. — No. 7. July 1951.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .211 .5 (493)]

The issue of passenger tickets on the Belgian National Railways,

by H. TALPAERT,
Inspecteur principal au Service des Finances de la S. N. C. B.,
and L. LATAIRE,
Ingénieur principal au Service des Finances de la S. N. C. B.

SUMMARY.

The issue of passenger tickets and keeping records of them for a total value of about 2.5 thousand million francs a year is one of the important tasks of the station staff; 5 % of the expenditure on « labour » for such staff is due to this work.

To these operating costs must be added those :

— of the travelling control services checking the station accounts;
— of the control services checking the returns;
— of the printing of the tickets.

These activities as a whole cost the S. N. C. B. about 70 million Belgian francs a year.

The object of the present report is to bring to the notice of the reader the *improvements* and *simplifications* offered by the use of machines for printing and recording the tickets at the booking office, *machines* of a completely novel type.

passengers enjoy (officer reservists, children, invalids, soldiers, etc.).

When the three classes are taken into account, this means that there are 15 scales of charges. This increases the number of divisions in the coupon racks, which affects the work of preparing the accounts, checking the documents and getting out statistics.

Fig. 1. — Simple pre-printed ticket to a single destination.

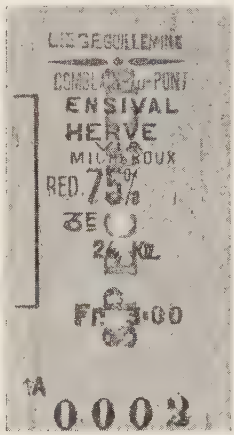

Fig. 2. — Simple pre-printed ticket to multiple destinations.

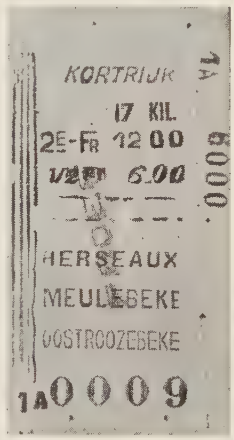

Fig. 3. — Simple pre-printed multiple destination ticket with bar.

Fig. 4. — Return ticket with bar to multiple destinations.

CHAPTER I.

Present position.
Issue of preprinted tickets stored in racks.

A. *The rates.*

The issue of tickets is complicated by the great number of cheap fares in force; in addition to the reduced rates granted for return tickets [1], there are reductions of 25 %, 50 % and 75 %, which many

The scales are proportional to the distance up to 30 km (18 miles); beyond 30 km they are based on zones (zones of 3 km [1.8 miles] from 31 to 60 km [19 to 37 miles] and 5 km [3 miles] above 60 km).

The existence of these rating zones makes it possible to include the names of several destination stations on the same ticket.

The use of multiple destination tickets reduces the number of divisions used in the racks and consequently the accountancy work.

[1] 15 % in January 1950.

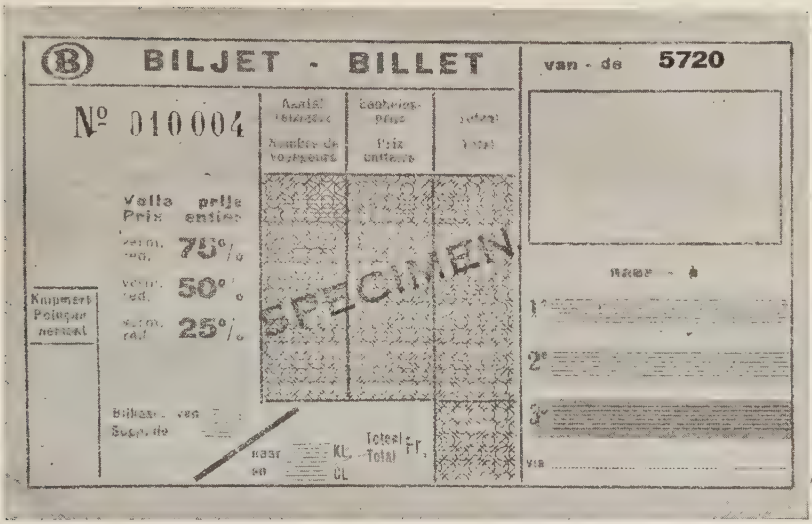

Fig. 5. — Single general purpose ticket (billet passe-partout).

Fig. 6. — Booking offices with vertical coupon racks.

B. *Coupon tickets and racks.*

Coupon tickets are of two types :

a) cardboard Edmonson tickets with a printed destination and fixed price (fig. 1, 2, 3 and 4) which represent 97 % of the output;

b) general purpose tickets (billets passe-partout) (fig. 5), which represent 3 % of the tickets sold.

Figures 3 and 4 show barred Edmonson tickets.

On such tickets there is a printed bar in which the booking clerk can write the name of any destination the fare to which is the same as that of the destination stations printed on the ticket.

Edmonson tickets are arranged in the booking offices in racks of the vertical type (fig. 6) or in modernised stations, in racks of the horizontal type (fig. 7).

The most important stations on the Belgian system have about 800 different categories of tickets per booking office window.

Fig. 7. — Modernised booking offices with horizontal racks.

C. *Administrative and accountancy work.*

In addition to the centralisation of the funds, the sale of tickets gives rise to the following administrative activities :

In the stations : — *At the central offices :*

1. *Stocking the tickets.*

In the stations :

— Preparing the demand notes for tickets (every six months or yearly according to the size of the station).

At the central offices :

— Checking the demands.
— Recording the demands.
— Printing the tickets.
— Checking and sending out the tickets.

In the stations :

— Receiving and checking the tickets.
— Storing them in the station stores.
— Entering them in on the stock sheets.
— Keeping the booking office supplied.

2. *Periodical lists of tickets sold.*

(every 10 days in large passenger stations; every 5 days in other stations).

In the stations :

— Establishing the number of tickets sold and the corresponding receipts.
— Checking these receipts against the total daily entries of the booking clerks.

3. *Monthly clerical work.*

In the stations :

— Establishing the monthly ticket sales (per classe and per rating category).
— Sending this statement to the central administration with the necessary documents (cancelled tickets, etc.).

At the central offices :

— Recapitulation of the station receipts and preparing the receipt statements for the whole railway.
— Checking the receipt statements of the stations.
— Checking the documents (cancelled tickets, etc.).
— Preparing statistics, per class and per category, of the number of tickets sold and corresponding receipts.

In the stations :

4. *Periodical checks.*

— Periodical check of the tickets in the station stores and reserves of the booking clerks.

— Checking the accounts of the distributors.

At the central offices :

— Checking the general purpose tickets with their stubs.

— Examining the tickets collected.

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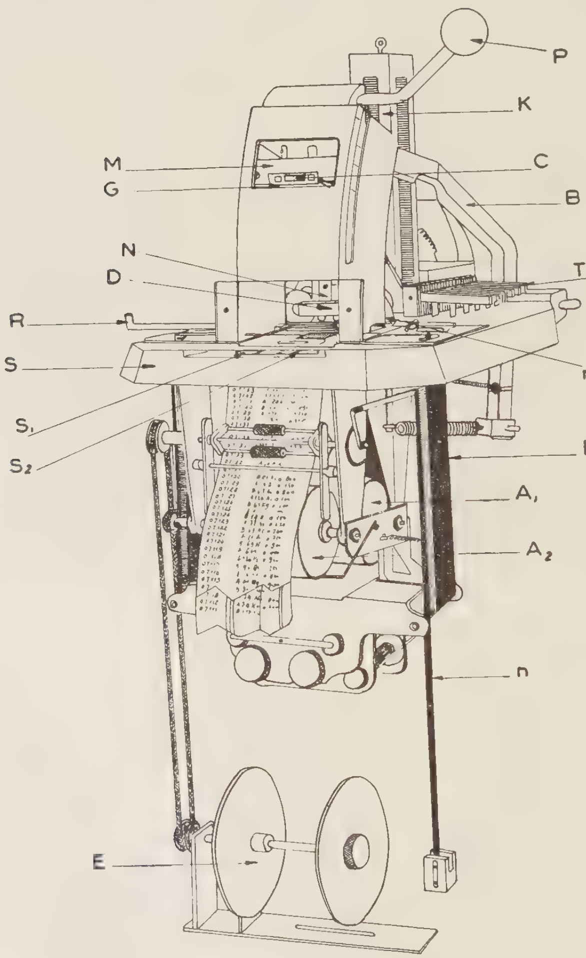


Fig. 8. — Machine with the case removed.

All these administrative operations, which are essential for proper accounting, are with justice considered to be a necessary evil; they are not the only drawback, however, of the system of preprinted tickets. The room taken in the booking offices by the ticket racks is another drawback, especially in the case of large stations.

Various German, Swedish and American firms have solved the problem of simplifying the issue of tickets, from the technical point of view, together with the accountancy, control and statistical services involved, by the use of printing and recording machines in the booking offices themselves.

Some of these solutions date from more

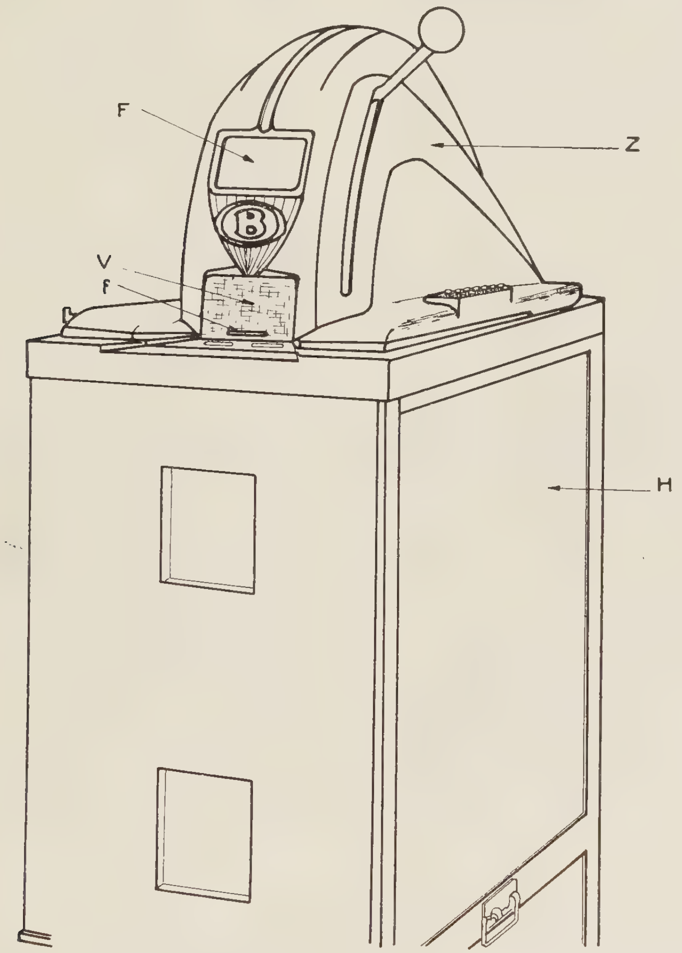


Fig. 9. — Machine with case in position fastened to the table.

than 10 years before the second world war, whilst others were perfected during that war.

Most of the European railways have equipped a limited number of their booking offices with machines of this kind. In Belgium for example 8 machines were in service in Brussels-Nord station since 1935. These were destroyed during the war in 1943, so that the problem of replacing them had to be faced at the end of hostilities.

CHAPTER II.

New solution.

Use of printing and recording machines.

During 1944, the S. N. C. B. became interested in a Belgian invention covering the construction of a machine to print the tickets in the booking office by means of zinc plates of the type used in adressing machines. In collaboration with the inventor, the S. N. C. B. perfected a printing and recording machine which met its own particular operating requirements in a practical and rational way.

On the 1st April 1949, ten of these machines were put into service in Brussels-Midi station; afterwards another three machines were added.

In addition, since the 1st June 1950, 11 machines have been in operation in Brussels-Nord station.

Consequently a total of 24 machines have been tested for some time under the heavy traffic conditions of important stations.

The S. N. C. B. systematically corrected any defects revealed in service by the first prototypes, so that now these machines have been perfected, and the S. N. C. B. has decided to mass produce them in its Electric and Signal Shops in order to generalise this method throughout the railway.

A. *Description of the machine* (1).

The printing and recording machine is of the adressing machine type. It consists (see fig. 8) of :

— a metal stand (S);

— a printing arm (B) with a lever to operate it by (P) and at the end of this a hammer (M) which carries the slides (G) intended to take the printing plates (C);

— a device (D) to print the name of the departure station with the mark (index-letters) of the machine;

— a moveable rail-dater (R);

— a device making it possible to print a bar on which can be written the name of any destination for which the fare is the same as that to the destination (s) on the ticket (not visible in the figure);

— a red ribbon (r) to print the check showing the authenticity of the ticket;

— a two coloured ribbon (b) for printing the ticket;

— a black ribbon (n) to print the accountancy recording band;

— an accountancy recording carbon (A^1) which leaves an impression on a duplicate band for checking purposes (A^2);

— an automatic winder (E) for the duplicate band;

(1) This machine is patented in all countries.

— a device (N) printing the number of the ticket at the same time as the check mark;

— a recording number on the bands (not visible in the figure);

— a case (K) holding blank tickets, with a capacity of at least 200 tickets;

— a device with keys (T) allowing the recording of occasional statistics;

The machine stands on a small table (fig. 9, H).

That part of the machine which is below the stand is enclosed in this table. The control band with the records unwinds automatically and is completely inaccessible to the operator.

The part of the machine above the stand is enclosed in a container of pleasing shape (fig. 9, Z).

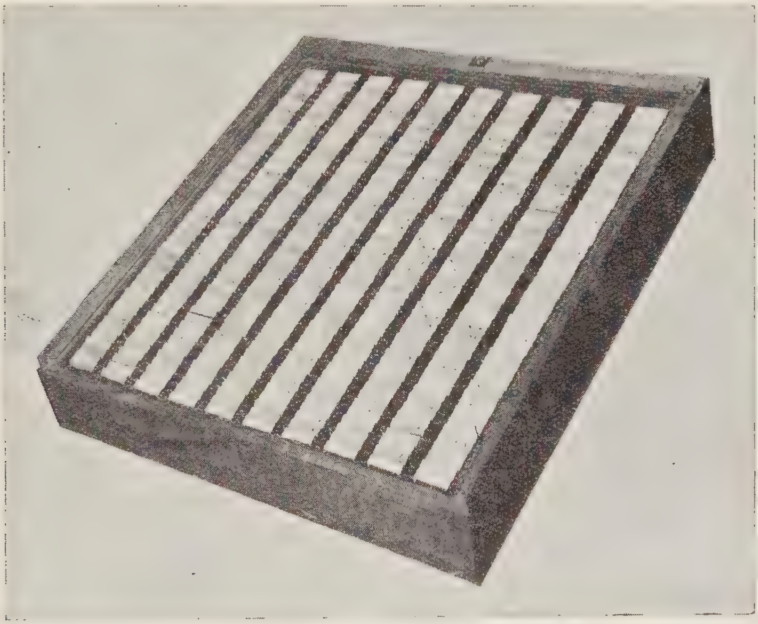


Fig. 10. — Box for holding plates.

— an indicator (S^1) showing when the bands come to an end;

— an indicator (S^2) showing when the supply of blank tickets runs out.

A numbered safety lead seal prevents the internal mechanism of the machine from being tampered with.

There is a window (F) in the container, to allow the plates to be inserted.

The unwinding of the accountancy recording band can be observed through a window (V) made of plexiglass, in which there is a slot through which the ticket is ejected.

As soon as the container is lifted off, the printing arm of the machine and tickets are locked.

In addition, an inner container protects the mechanism printing the tickets and the recording bands.

Boxes of plates (fig. 10) to complete the equipment are stacked on the right and if necessary on the left of the operator.

The capacity of these boxes varies according to the requirements of the booking office in question. There is no difficulty in having as many as 2 800 plates, although the most important booking offices of the S. N. C. B. do not require more than a maximum of 800 plates.

B. *Description of the plates.*

The plates (fig. 11) are made of electrolytic zinc like those used in adressing machines. They have lateral V shaped rims which strengthen them and prevent them bending, as well as guiding them in the slides. There is a rim in front by which the plate can be held when filed vertically in the boxes, which is also used to carry the label.

The text carried on the plates by stamping the zinc includes :

1st line, 2nd », 3rd », 4th » — names of destination station (4 at most).

5th line — the index of the destinations on the plate, i. e. the mileage preceded by a series letter;
— the cost of the ticket.

6th line — a combination of two letters forming the index mark of the machine. (This index figure is also reproduced at the top of the printing.)

7th line — the characteristic of the ticket from the rating point of view. The plate shown in figure 11 is a single rate ticket, 3rd class, 50 %.

The class of ticket is shown in the centre above the 6th and 7th lines of print.

8th line — All the information to be printed by the plate on the recording bands (check and accountancy bands), i. e. :

Indexes of destination	Index no. of machine	Code (1) for ticket characteristic	Receipts
A 70	Na	2	49.—

The plates are filed vertically in the boxes (see fig. 10). As will be seen, the frontal projection mentioned above is facing the operator.

C. *The working of the machine.*

To issue a ticket to a passenger, the booking clerck :

— takes the plate for the journey in question out of the box;

— puts the plate into the slide;

(1) The code is printed by the plate on the recording bands in order that the receipts may ultimately be classified by class and category of reduction.

— presses the operating lever and thus prints simultaneously the wording on the ticket and the necessary indications on the recording bands, ticket and bands being numbered alike;

— lets the printing block rise up again, thus automatically ejecting the ticket through *f* of figure 9;

— hands the ticket to the passenger;

— replaces the plate in its box.

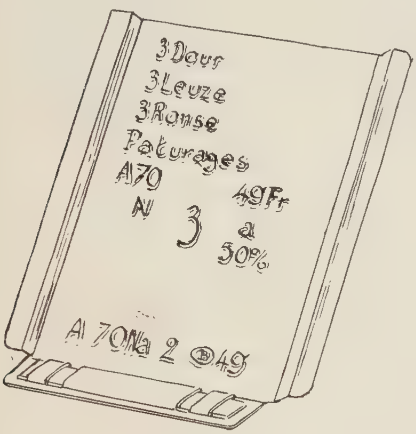


Fig. 11. — Plate.

When the booking clerk has to issue a ticket with a bar, he presses on a regulator at the same time as he puts the plate into the slides.

The speed at which such tickets can be issued is at least as fast as that obtaining with the old type of preprinted ticket.

D. *Shape of the tickets.*

The tickets are of the Edmonson type. The cardboard used is covered with a very sensitive colouring which disappears if a rubber or chemical ink eraser is used on it. The same colour is used for all three classes. Certain details are printed in black, others in red. We show examples of tickets printed by these machines in figures 12, 13 and 14.

The use of the machine does not necessarily mean that the tickets must be like this. They can be varied as desired, each line of the plate having 13 letters or figures, and the ticket consisting of 4 lines printed by arrangements in the machine and 7 by the plate.

E. *Recording bands.*

The recording band is printed in duplicate; the original is used for the station accounts and the duplicate copy as a control by the central administration.

Figure 15 shows a recording band, giving the following details :

1) the continuous order number of the record of the receipt; the same number is shown in red figures on the ticket;

2) the information given on the last line of the plate, i. e. :

— the index of the destination;

— the index number of the machine;

— the number of the characteristic code of the category of ticket;

— the price of the ticket, i. e. the receipt.

3) if necessary, in the right hand margin, there is a statistical number printed by operating one of the statistical keys on the machine (T, fig. 8).

All the data given in columns 2 to 5 of the recording band, i. e. those printed by the plate itself, can be adapted to the accountancy and statistical requirements of each railway. In this way the recording band can show the part of the receipt to

3 NEW TICKETS.

Fig. 12. — Single full fare 1st class ticket for multiple destinations, printed by machine No. Aa.

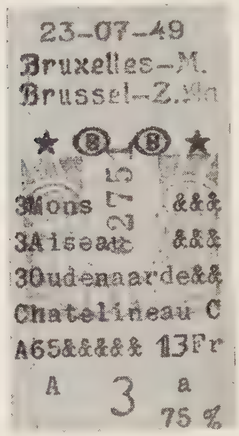


Fig. 13. — Single 3rd cl. ticket at reduced fare (75 %) to multiple destinations, printed by machine Aa.

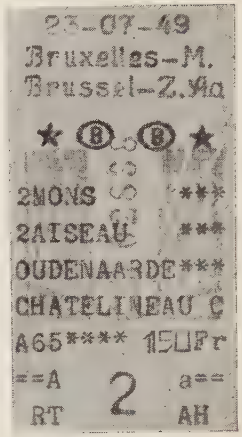


Fig. 14. — 2nd class return ticket to multiple destinations, printed by machine No. Aa

Part printed by the machine's number plate	Part printed by the last line of the plate				Part printed bij the occasional statistics device
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
Continuous order No.	Index of destin-ations	Index of machine	Charact-eristic code of ticket	Receipt	Statistics
62 800	A 100	Na	7	⊕137	-
62 799	A 120	Na	13	⊕240	-
62 798	B 48	Na	5	⊕19	4
62 797	A 70	Na	2	⊕93	-
62 796	A 85	Na	1	⊕67	-
62 795	A 7	Na	3	⊕4 5	1
62 794	B 45	Na	9	⊕47	3
62 793	A 65	Na	17	⊕64	6
62 792	B 25	Na	12	⊕9	9
62 791	A 30	Na	6	⊕6 5	11
62 790	A 26	Na	11	⊕19	10

Fig. 15. — Reproduction of a recording band.

be allocated to other railways if the machine is used for through tickets.

F. *Accountancy work in the station.*

The accountancy of the tickets sold merely means adding up the price of the tickets.

This is done in the large stations by up to date adding machines, at the rate of 3 500 items an hour.

To make sure the addition has been made correctly, it is done twice; if the totals of the first and second additions do not agree, i. e. to within about 10 %, it is done again a third time.

The total hourly output is therefore about 1 650 items an hour. In the case of a booking office having an average output of 360 tickets, the daily accounts only take 13 minutes to do, i. e. 6 1/2 hours a month, which is appreciably less than the time now taken to do the accounts for fixed price tickets (periodical and monthly accounts), and checking these accounts.

On the basis of a total sale of 6 700 000 tickets a month over the whole railway, the time devoted by the station staff to ticket accounts is as follows :

— at the present time :

36 000 hours a month;

— with these machines :

4 175 hours a month.

The new system makes it possible to effect appreciable savings in the staff employed in the large stations and lightens the work in the less important stations.

The bands can be added up day by day during the month, and the accounts completed monthly without adding to the work.

If several men have issued tickets from the same machine, it is easy to note the position of the numbering device when they took over from each other, and divide up the additions so as to ascertain the receipts per man.

G. *Statistics.*

1) Permanent statistics.

a) *Sales and receipts per class and category of rate.* — The passenger rates on the S. N. C. B. are divided into 3 classes and 5 tariff groups, so it is essential to ascertain at more or less short intervals the distribution of the receipts and the number of tickets sold for each class and each rate.

These statistics are obtained when the old accountancy methods are used by inserting the numbers of tickets sold by the stations and the corresponding receipts in 15 different columns and analysing each of these columns for all the stations on the system.

This could no longer be done with the recording bands on which the receipts are given in a single column, so it became essential to give each plate a characteristic index figure corresponding to the class and category of ticket being printed. The automatic reproduction of this index on the recording band enables the band to be analysed later on.

This analysis, the extent and frequency of which may vary according to the period of the year and the requirements of the statistical department, is done on the S. N. C. B. by means of multiple comptometers, one of which is shown in figure 16.

b) *Passengers-km.* — The S. N. C. B. can ascertain the number of passengers-km from the receipts by dividing the latter by the unit passenger-km receipt, as the rates are proportional to the distance.

On railways where the receipts are not proportional to the distance it would be necessary to find the average distance per ticket by adding up the mileages given on the recording bands.

2) Occasional statistics.

By fitting the printing machine with statistical apparatus, the S. N. C. B. has enabled the most varied statistical probes to be carried out as required.

For example certain railways may require to know the receipts obtained from certain reduced fares for which they receive compensation from the Government. To do so they merely have to mark the recording bands with a statistical index figure, and then analyse a certain number of bands. Such an analysis will only cost very little more; it can be done at the same time as the other analyses mentioned under 1°, *a*, above.

Fig. 16. — Multiple comptometer machine used to analyse the control bands.

H. *Making the plates.*

Modification of the fares should the tariff be changed.

The plates are made of electrolytic zinc. The stamping of text is done at the central office by means of a die stamp of the same type as those used for the plates of addressing machines. However the plate carrier is specially built for these plates in view of their special shape (see chapter II, *B*, above).

In addition the die stamps use a special type, special to the S. N. C. B.

Figure 17 shows a stamping machine used by the S. N. C. B. *C* shows the carrier holding the plate to be stamped, and *A* and *B* the turning discs one of which carries the male and the other the female part of the dies.

The text stamped on the plates can be restamped at least six times by the die stamper.

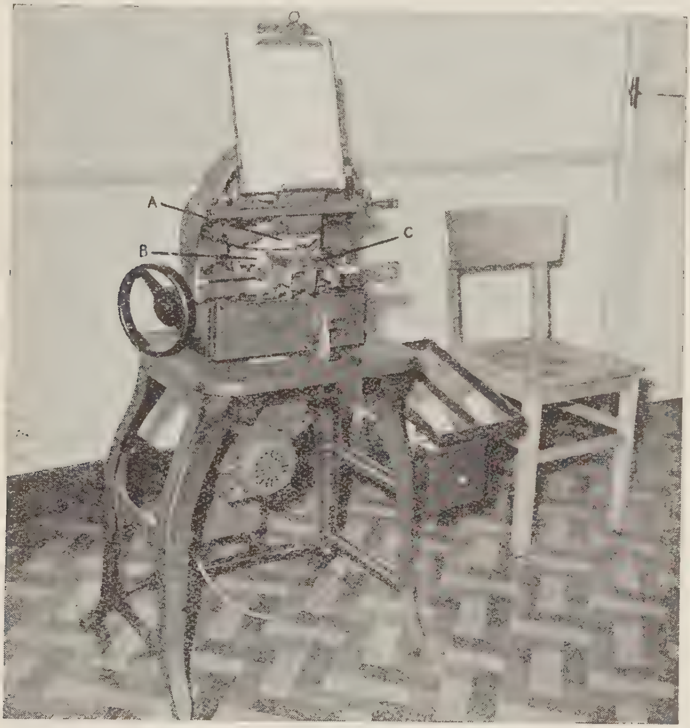


Fig. 17. — Machine used for die stamping the plates.

When a ticket printing machine is put into service, the station in question is provided with a complete set of plates showing the fares in force at the time. A second set of plates, without any fares

stamped on them, is stored at the central office, and when the rates are changed, as soon as the new scale of charges has been approved, the spare plates are to the central administration, which effaces the old figures and stores the plates until they are required when the fares are changed once more.

Fig. 18. — Booking office window with machine without its case, and boxes of plates. View taken from the interior of the booking office.

stamped with the new rates and sent to the station the evening before they come into force. The old set of plates is returned

This simple and speedy procedure is one of the greatest advantages of the new method of printing the tickets.

I. *Frauds.*

The S. N. C. B. has succeeded in fitting these machines with effective safety devices.

Fig. 19. — Booking office with machine.
View from the passengers side.

CHAPTER III.

A. *Advantages of the new method of distribution.*

From the above report it will be seen that the recording-printing machine perfected by the S. N. C. B. with the collaboration of its inventor has the following advantages :

1. Simplicity and robustness of construction; easy maintenance.
2. Moderate price, so that it is possible to equip a great many stations with such machines.
3. Total suppression of the tiresome accountancy operations, the ticket accounts being merely a matter of adding up the prices.

4. Suppression of printing Edmonson tickets and holding stocks of such tickets in the stations.
5. Suppression of controlling the stocks of tickets.
6. Suppression of demand sheets for tickets.
8. Great facility for employing different men to operate the machine in the booking office, when the clerks work in shifts.
9. Speed of distribution at least as fast as that obtained in the case of pre-printed tickets.

Fig. 20. — Row of booking office windows. View from the interior of the booking office

7. Possibility, should the rates be altered, of providing tickets showing the new rates, without erasure or surcharge, the first day the new rates come into force.
10. Possibility of appreciably reducing the number of general purpose tickets (billets passe-partout), on the one hand by using a greater number of plates, the price of which is small, and

the space occupied small, and on the other hand by the use of the printed bar.

The issue of general purpose tickets slows down the issue of tickets and makes it necessary for the central Administration to carry out very strict controls.

11. Practically unlimited possibility as regards statistics, thanks to :
    - the codification of the plates;
    - the use of key statistical printers;
    - the analysis of the record bands by means of multiple comptometers breaking down the different factors simultaneously.

12. Possibility of modifying the scope of the statistics without changing the work of the stations.

13. Reduction of the space required in the booking offices.

14. Modernisation of the aspect of the offices (see fig. 18, 19 and 20).

15. Possibility of the booking clerk working in a comfortable position.

B. *Future prospects.*

In view of the simplicity, the robust construction and the moderate cost of the machine, the S. N. C. B. has decided to equip all stations with an output of at least 2 000 tickets a month with such machines.

In this way, 780 booking offices in 550 stations will be equipped with these machines.

The other stations with a low output (less than 2 000 tickets a month), which number 560, will be supplied every month with tickets from a given neighbouring station equipped with the machines, which will make it possible to extend the advantages of the new method of issuing tickets to the whole of the system.

[625 .14 (01 & 625 .2 (01]

Wheel and Rail,

(Continued),*

by P. LABRIJN, (†)

Former pupil of Delft Polytechnic, Assistant Chief Engineer Locomotive and Rolling Stock Department, Netherlands Railways

Trial arrangement for determining the coefficient of friction between rail and wheel.

With the aim of determining the coefficient of friction f'' between rail and wheel in the case where the wheel, whilst rotating, slides transversely and longitudinally at the same time, trials have been carried out with a train of vehicles, to a scale of 1 : 5, as shewn in figure 42.

The train comprises two vehicles, A and B. A has two axles, the wheels of which have flanges, whilst B has a single axle and wheels without flanges. The axle of vehicle B is the test axle.

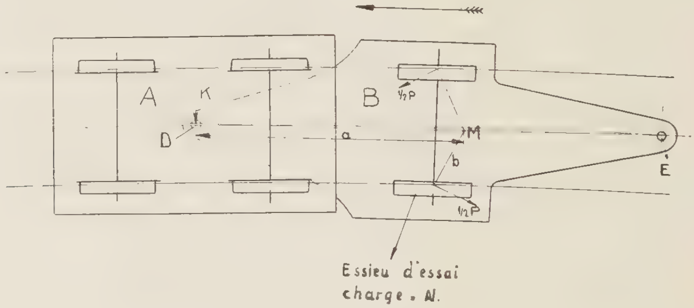
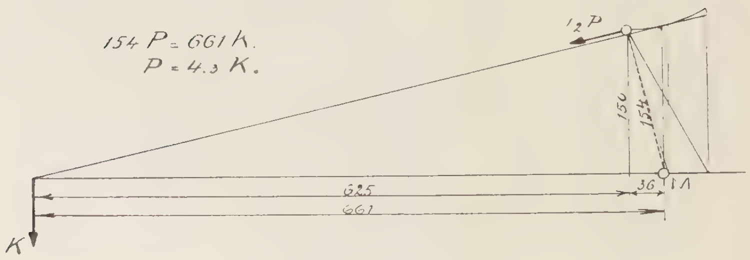


Fig. 42.

Explanation of French terms :
Essieu d'essai = Test axle. — Charge N = Load N



Single axle vehicle.
Fig. 43.

(*) See *International Railway Congress Bulletin*, for May 1951, p. 255.

The set is located in a curve of $\frac{120}{5}$ = 24 m radius (measured at the centre line of the track) and running in the direction shown by the arrow. Vehicle B is coupled to a point D of vehicle A, so that the transverse force exerted at this point on vehicle A can be measured. The point M on which the trial axle pivots was determined by the HEUMANN method (see fig. 43) which gave the position of the point M as 36 mm behind the trial axle.

We have :

$$Ka = 2 \times 1/2\ Pb$$

or :

$$P = K \frac{a}{b}$$

Substituting the values mentioned in figure 43, we get :

$$P = 4.3\ K.$$

This set of vehicles was set in motion, applying various values as follows :

a) angles of bearing for the test axle of 0°, 0° 30′ and 1°;

b) an axle load on rail of 81 and 241 kg and intermediate weights;

c) test axle braked and unbraked.

During the trials, the following details were recorded :

1. the guiding force K;

2. the degrees of slide or longitudinal skid of the two wheels of the test axle;

3. the curves described by the two points D and E whilst running through a curve.

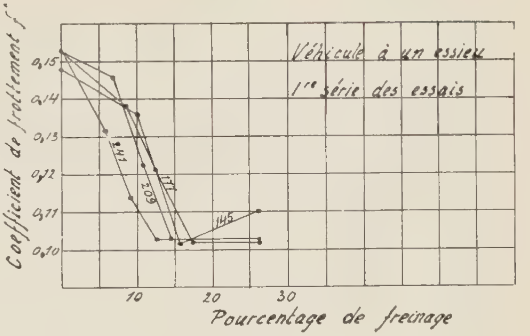


Fig. 44.

Explanation of French terms :

Véhicule à un essieu, 1re série des essais = Single axled vehicle, 1st. series of tests. — Coefficient de frottement f″ = Co-efficient of friction f″. — Pourcentage de freinage. = Brake percentage.

The force P is calculated as a function of the guiding force K, from which is obtained the co-efficient of friction :

$$f'' = \frac{P}{N}$$

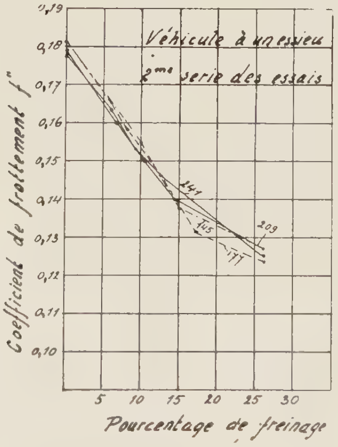


Fig. 45.

Explanation of French terms :

Véhicule à un essieu, 2e série des essais = Single axled vehicle 2nd series of tests. — Coefficient de frottement f″ = Co-efficient of friction f″. — Pourcentage de freinage = Brake percentage.

TABLE X.

Single axle vehicle. — Test axle not braked.

Initial position of test axle	Axle load	Guiding force	Frictional force	Co-effic. of friction	Slide (—) or Slip (+) after 5 turns of the wheels		Distance of the centre line of the track from the point	
	N	K	P = 4.3 K	$f'' = \frac{P}{N}$	outer	inner	E	D
—	kg	kg	kg	—	mm	mm	mm	mm
0°	81	2.8	12.0	0.148	— 31	+ 11	4.5	0.5
	113	3.8	16.3	0.144	— 31	+ 11	4.5	0.5
	145	5.0	21.5	0.148	— 31	+ 11	4.5	0.5
	177	6.3	27.1	0.153	— 33	+ 8	4.5	0.5
	209	7.5	32.2	0.153	— 37	+ 5	4.5	0.5
	241	8.6	37.0	0.153	— 36	+ 6	4.5	0.5
0° 30′	81	2.8	12.0	0.148	— 25	+ 17	15	10.5
	113	3.8	16.3	0.144	— 22	+ 20	15	10.5
	145	5.0	21.5	0.148	— 23	+ 19	15	10.5
	177	6.3	27.1	0.153	— 25	+ 17	15	10.5
	209	7.5	32.2	0.153	— 26	+ 16	15	10.5
	241	8.6	37.0	0.153	— 26	+ 16	15	10.5
1°	81	2.8	12.0	0.148	— 19	+ 23	26	21
	113	3.8	16.3	0.144	— 20	+ 22	26	21
	145	5.0	21.5	0.148	— 20	+ 22	26	21
	177	6.3	27.1	0.153	— 19	+ 23	26	21
	209	7.5	32.2	0.153	— 20	+ 22	26	21
	241	8.6	37.0	0.153	— 20	+ 22	26	21

The trials were repeated after an interval of two months.

The results of the first series of tests are contained in Tables X and XI, and those of the second series in Tables XII and XIII. These results are shewn graphically in figures 44 (first series) and 45 (second series).

The following conclusions can be drawn :

By causing vehicle B to be moved forward by vehicle A, the test axle takes up an almost radial position, even though the axle is originally located at an angle on the track. Vehicle B moves forward at first in a certain oblique position in relation to the test axle, in such a way that the centre of the axle does not remain on the centre of the track but moves towards the outside for a certain distance

TABLE XI.

Single axle vehicle. — Test axle braked.

itial sition test xle	Axle load	Brake block pressure	as % of wheel load	Guiding force	Frictional force	Co-effic. of friction	Slide (—) or Slip (+) after 5 turns of the wheels		Distance of the centre line of the track from the point E	Distance of the centre line of the track from the point D
	N			K	P = 4.3 K	$f'' = \frac{P}{N}$	outer	inner	+ tow. outside — tow. inside	
—	kg	kg	—	kg	kg	—	mm	mm	mm	mm
0°	81	22	27	2.0	8.6	0.106	— 64	— 22	4.5	0.5
	113	30	27	2.8	12.0	0.106	— 62	— 20	4.5	0.5
	145	14	9.7	4.6	19.8	0.136	— 46	— 4	4.5	0.5
	145	22	15.2	3.8	15.9	0.116	— 42	0	4.5	0.5
	145	38	26	3.7	15.9	0.110	— 52	— 12	4.5	0.5
	177	14	7.9	5.7	24.5	0.139	— 39	— 3	4.5	0.5
	177	22	12.4	5.0	21.5	0.121	— 42	0	4.5	0.5
	177	30	17	4.2	18.0	0.102	— 42	0	4.5	0.5
	177	46	26	4.2	18.0	0.102	— 46	— 4	4.5	0.5
	209	14	6.7	7.1	30.5	0.146	— 39	+ 3	4.5	0.5
	209	22	10.5	6.0	25.8	0.123	— 43	— 1	4.5	0.5
	209	30	14.5	5.0	21.5	0.103	— 42	0	4.5	0.5
	209	54	26	5.0	21.5	0.103	— 44	— 2	4.5	0.5
	241	14	5.8	7.4	31.8	0.132	— 39	+ 3	4.5	0.5
	241	22	9.1	6.4	27.5	0.114	— 40	+ 2	4.5	0.5
	241	30	12.5	5.8	24.9	0.103	— 42	0	4.5	0.5
	241	62	26	5.8	24.9	0.103	— 44	— 2	4.5	0.5
30′	81	22	27	2.0	8.6	0.106	— 60	— 18	15	10.5
	113	30	27	2.8	12.0	0.106	— 60	— 18	15	10.5
	145	38	26	3.7	15.9	0.110	— 54	— 12	15	10.5
	177	46	26	4.2	18.0	0.102	— 48	— 6	15	10.5
	209	54	26	5.0	21.5	0.103	— 42	0	15	10.5
	241	62	26	5.8	24.9	0.103	— 44	— 2	15	10.5
°	81	22	27	2.0	8.6	0.106	— 62	— 20	26	21
	113	30	27	2.8	12.0	0.106	— 60	— 18	26	21
	145	14	9.7	4.6	19.8	0.136	— 36	+ 6	26	21
	145	22	15.2	3.8	15.9	0.116	— 41	+ 1	26	21
	145	38	26	3.7	15.9	0.110	— 52	— 10	26	21
	177	14	7.9	5.7	24.5	0.139	— 30	+ 12	26	21
	177	22	12.4	5.0	21.5	0.121	— 39	+ 3	26	21
	177	30	17	4.2	18.0	0.102	— 43	— 1	26	21
	177	46	26	4.2	18.0	0.102	— 46	— 4	26	21
	209	14	6.7	7.1	30.5	0.146	— 34	+ 8	26	21
	209	22	10.5	6.0	25.8	0.123	— 38	+ 4	26	21
	209	30	14.5	5.0	21.5	0.103	— 41	+ 1	26	21
	209	54	26	5.0	21.5	0.103	— 42	0	26	21
	241	14	5.8	7.4	31.8	0.132	— 36	+ 6	26	21
	241	22	9.1	6.4	27.5	0.114	— 38	+ 4	26	21
	241	30	12.5	5.8	24.9	0.103	— 42	0	26	21
	241	62	26	5.8	24.9	0.103	— 44	— 2	26	21

TABLE XII.

Single axle vehicle. — Test axle not braked.

Initial position of test axle	Axle load	Guiding force	Frictional force	Co-effic. of friction	Slide (—) or Slip (+) after 5 turns of the wheels		Distance of the centre line of the track from the point	
	N	K	P = 4.3 K	$f'' = \frac{P}{N}$	outer	inner	E	D
—	kg	kg	kg	—	mm	mm	mm	mm
0°	81	3.5	15.1	0.182	— 31	+ 11	+ 4.5	— 0.5
	113	4.8	20.6	0.183	— 31	+ 11	+ 4.5	— 0.5
	145	6.1	25.8	0.181	— 31	+ 11	+ 4.5	— 0.5
	177	7.3	31.4	0.181	— 33	+ 8	+ 4.5	— 0.5
	209	8.7	37.4	0.179	— 37	+ 5	+ 4.5	— 0.5
	241	10	43	0.178	— 36	+ 6	+ 4.5	— 0.5
0° 30′	81	3.5	15.1	0.182	— 25	+ 17	+ 15	+ 10.5
	113	4.8	20.6	0.183	— 22	+ 20	+ 15	+ 10.5
	145	6.1	25.8	0.181	— 23	+ 19	+ 15	+ 10.5
	177	7.3	31.4	0.181	— 25	+ 17	+ 15	+ 10.5
	209	8.7	37.4	0.179	— 26	+ 16	+ 15	+ 10.5
	241	10	43	0.178	— 26	+ 16	+ 15	+ 10.5
1°	81	3.5	15.1	0.182	— 19	+ 23	+ 26	+ 21
	113	4.8	20.6	0.183	— 20	+ 22	+ 26	+ 21
	145	6.1	25.8	0.181	— 20	+ 22	+ 26	+ 21
	177	7.3	31.4	0.181	— 19	+ 23	+ 26	+ 21
	209	8.7	37.4	0.179	— 20	+ 20	+ 26	+ 21
	241	10	43	0.178	— 20	+ 20	+ 26	+ 21

when the axle will continue to run on its course. The distances of the points D and E from the centre line of the track are noted in Tables X to XIII, these distances being determined by the vehicle itself.

Figure 46 shews a reduced image of the curves traced by the point E.

The results allow the following deductions :

1. The standard and state of the track influence to a large extent the co-efficient of friction f''. From the first series of trials, the overall value of f'' was 0.15, from the second series 0.18.

2. The co-efficient of friction does not depend on the wheel loading.

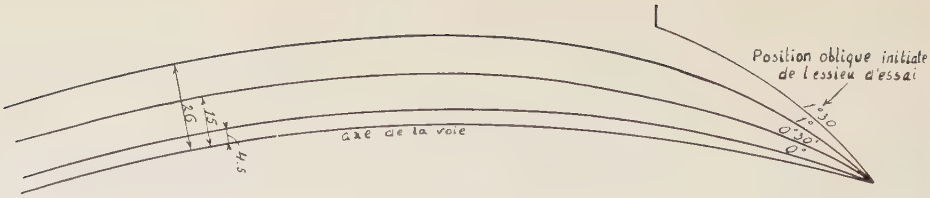
3. On the axle braked with the following ratio :

$$\left(\text{ratio } \frac{\text{brake block effort}}{\text{weight on rail}}\right)$$

TABLE XIII.

Single axle vehicle. — Test axle braked.

itial sition test xle	Axle load	Brake block pressure		Guiding force	Frictional force	Co-effic. of friction	Slide (—) or Slip (+) after 5 turns of the wheels		Distance of the centre line of the track from the point	
			as % of wheel load						E	D
	N			K	P = 4.3 K	$f'' = \frac{P}{N}$	outer	inner	+tow. outside —tow. inside	
—	kg	kg	—	kg	kg	—	mm	mm	mm	mm
0°	81	22	27	2.4	10.3	0.127	— 63	— 21	+ 4.5	— 0.5
	113	30	27	3.4	14.6	0.129	— 61	— 19	+ 4.5	— 0.5
	145	14	9.7	5.2	22.4	0.154	— 38	+ 4	+ 4.5	— 0.5
	145	22	15.2	4.6	19.8	0.137	— 42	0	+ 4.5	— 0.5
	145	38	26	4.3	18.4	0.127	— 55	— 13	+ 4.5	— 0.5
	177	14	7.9	6.5	28.0	0.158	— 39	+ 3	+ 4.5	— 0.5
	177	22	12.4	6.0	25.8	0.146	— 42	0	+ 4.5	— 0.5
	177	30	17	5.4	23.2	0.131	— 42	0	+ 4.5	— 0.5
	177	46	26	5.1	21.9	0.124	— 44	— 2	+ 4.5	— 0.5
	209	14	6.7	7.8	33.5	0.160	— 39	+ 3	+ 4.5	— 0.5
	209	22	10.5	7.3	31.4	0.150	— 43	— 1	+ 4.5	— 0.5
	209	30	14.5	6.8	29.2	0.139	— 42	0	+ 4.5	— 0.5
	209	54	26	6.2	26.6	0.127	— 42	0	+ 4.5	— 0.5
	241	14	5.8	9.2	39.5	0.164	— 39	+ 3	+ 4.5	— 0.5
	241	22	9.1	8.6	37.0	0.153	— 40	+ 2	+ 4.5	— 0.5
	241	30	12.5	8.2	35.2	0.146	— 42	0	+ 4.5	— 0.5
	241	62	26	7.0	30.0	0.125	— 42	0	+ 4.5	— 0.5
30′	81	22	27	2.4	10.3	0.127	— 60	— 18	+15	+10.5
	113	30	27	3.4	14.6	0.129	— 60	— 18	+15	+10.5
	145	38	26	4.3	18.4	0.127	— 54	— 12	+15	+10.5
	177	46	26	5.1	21.9	0.124	— 48	— 6	+15	+10.5
	209	54	26	6.2	26.6	0.127	— 42	0	+15	+10.5
	241	62	26	7.0	30.0	0.125	— 44	— 2	+15	+10.5
1°	81	22	27	2.4	10.3	0.127	— 62	— 20	+26	+21
	113	30	27	3.4	14.6	0.129	— 60	— 18	+26	+21
	145	14	9.7	5.2	22.4	0.154	— 36	+ 6	+26	+21
	145	22	15.2	4.6	19.4	0.137	— 41	— 1	+26	+21
	145	38	26	4.3	18.4	0.127	— 52	— 10	+26	+21
	177	14	7.9	6.5	28.0	0.158	— 30	+ 12	+26	+21
	177	22	12.4	6.0	25.8	0.146	— 39	+ 3	+26	+21
	177	30	17	5.4	23.2	0.131	— 43	— 1	+26	+21
	177	46	26	5.1	21.9	0.124	— 46	— 4	+26	+21
	209	14	6.7	7.8	33.5	0.160	— 34	+ 8	+26	+21
	209	22	10.5	7.3	31.4	0.150	— 38	+ 4	+26	+21
	209	30	14.5	6.8	29.2	0.139	— 41	+ 1	+26	+21
	209	54	26	6.2	26.6	0.127	— 42	0	+26	+21
	241	14	5.8	9.2	39.5	0.164	— 36	+ 6	+26	+21
	241	22	9.1	8.6	37.0	0.153	— 38	+ 4	+26	+21
	241	30	12.5	8.2	35.2	0.146	— 42	0	+26	+21
	241	62	26	7.0	30.0	0.125	— 40	+ 2	+26	+21



Ratio $\dfrac{\text{longitudinal scale}}{\text{transverse scale}} = \dfrac{1}{8}$

Single axle vehicle. Curve followed by point E (see fig. 42).

Fig. 46.

Explanation of French terms :

Position oblique initiale de l'essieu d'essai = Initial oblique position of test axle. — Axe de la voie = Centre line of track.

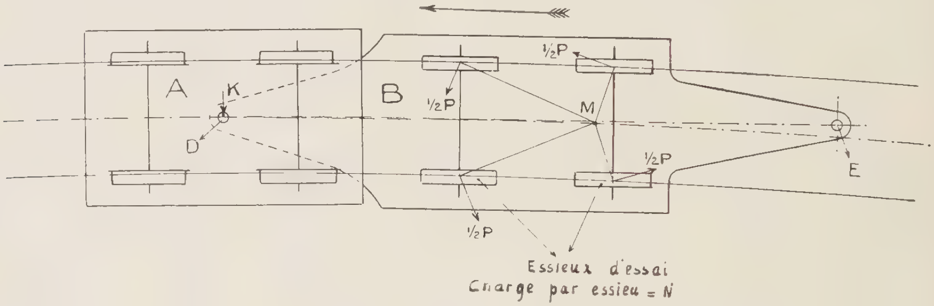


Fig. 47.

Explanation of French terms :

Esieux d'esssai = Test axles. — Charge par essieu = N = Load per axle = N

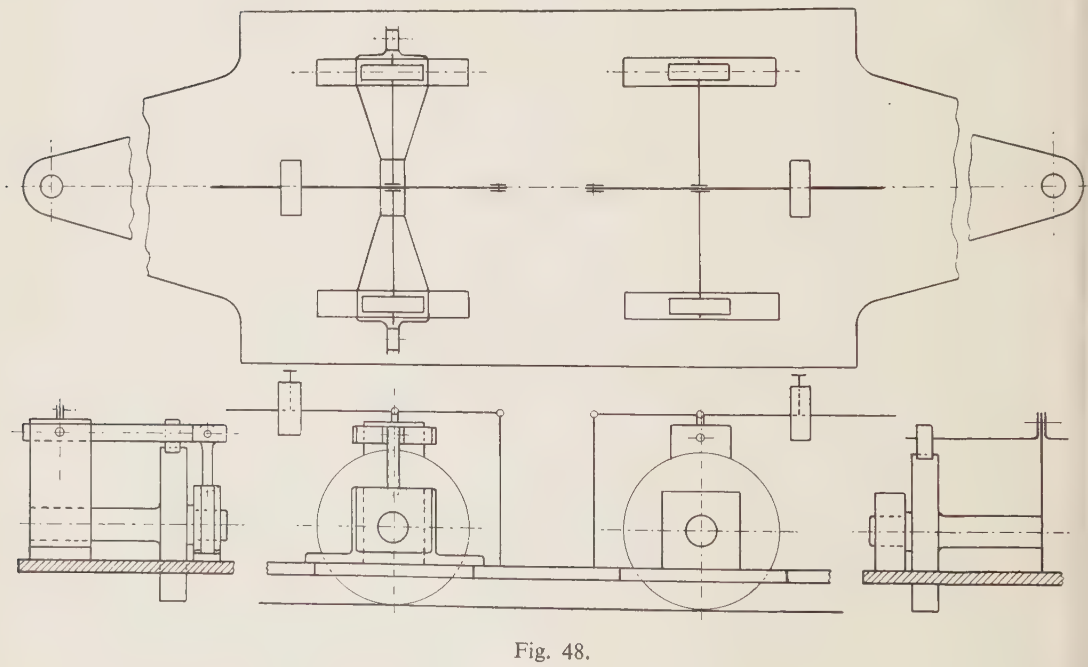


Fig. 48.

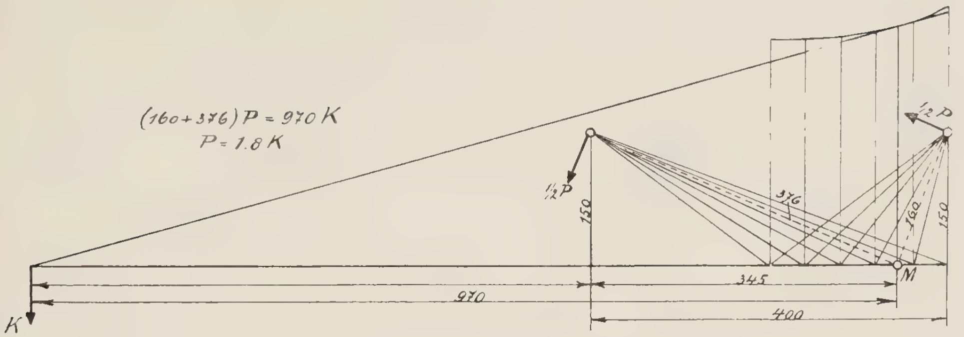


Fig. 49. — Two axled vehicle.

at 26-27 %, the value of the co-efficient of friction f'' is lower than with the braked axle. In this case, the value of the co-efficient of friction f'' is lower than with the axle not braked. In this case, the value of the co-efficient of friction f'' is independent of the load on the wheels. The values of f'' are nearly 0.10 and 0.125.

4. The values of the co-efficient of friction f'', for an axle with a braking force arranged to increase progressively, should have a co-efficient f'' which progressively decreases.

5. Tables X to XIII shew that the co-efficient f'' is reduced almost proportionately from 0.15 to 0.10 and 0.18 to 0.14 if the brake proportion increases from 0 to about 15 %. With a brake percentage in excess of 15 %, the co-efficient f'' is greatly reduced.

6. In a 24 m radius curve (measured at the centre of the track) the outer wheel of the unbraked axle slides whilst the inner wheel slips along. The slide of the outer wheel is always stronger than the slipping of the inner wheel.

7. In the same curve, the sliding of the outer wheel of the braked axle increases and the longitudinal slipping of the inner wheel decreases in such a way that the inner wheel no longer slips and the slipping is changed to a slide.

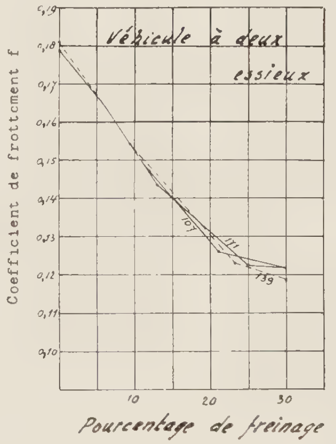


Fig. 50.

Explanation of French terms :

Véhicule à deux essieux = Two axled vehicle. — Coefficient de frottement f = Co-efficient of friction f. — Pourcentage de freinage = Brake percentage.

In order to obtain additional figures, the tests were repeated with a set of vehicles, of which vehicle B was fitted with 2 axles, as in figures 47 and 48. One of the axles was fitted with a transverse equaliser to ensure a constant distribution of the load on the wheels.

TABLE XIV.

Two axled vehicle. — Test axles not braked.

Initial position of test axle	Axle load	Guid. force	Frictional force	Co-effic. of friction	Slide (—) or Slip (+) after 5 turns of the wheels				Distance of the cen line of the tracl from the point	
					leading axle		rear axle		E	D
	N	K	P = 1.8 K	$f'' = \frac{P}{N}$	outer	inner	outer	inner	+ tow. outside — tow. inside	
	kg	kg	kg	—	mm	mm	mm	mm	mm	mm
0°	75	7.5	13.5	0.18	— 24	+ 18	— 17	+ 25	— 10	0
	107	10.8	19.4	0.181	— 24	+ 18	— 14	+ 28	— 10	0
	139	14	25.2	0.181	— 24	+ 18	— 12	+ 30	— 10	0
	171	17	30.6	0.179	— 24	+ 18	— 14	+ 28	— 10	0
	203	20.4	36.8	0.178	— 25	+ 17	— 14	+ 28	— 10	0
0° 30′	75	7.5	13.5	0.18	— 24	+ 18	— 14	+ 28	0	+ 14.
	107	10.8	19.4	0.181	— 24	+ 18	— 16	+ 26	0	+ 14.
	139	14	25.2	0.181	— 24	+ 18	— 15	+ 27	0	+ 14.
	171	17	30.6	0.179	— 24	+ 18	— 14	+ 28	0	+ 14.
	203	20.4	36.8	0.178	— 24	+ 18	— 15	+ 27	0	+ 14.
1°	75	7.5	13.5	0.18	— 24	+ 18	— 15	+ 27	+ 10	+ 28.
	107	10.8	19.4	0.181	— 24	+ 18	— 15	+ 27	+ 10	+ 28.
	139	14	25.2	0.181	— 24	+ 18	— 16	+ 26	+ 10	+ 28.
	171	17	30.6	0.179	— 24	+ 18	— 14	+ 28	+ 10	+ 28.
	203	20.4	36.8	0.178	— 24	+ 18	— 15	+ 27	+ 10	+ 28.

The position of the frictional pivot was again determined by the HEUMANN method (see fig. 49).

The results obtained are shewn in Tables XIV and XV and, graphically in figure 50.

It is shewn by the foregoing that the results obtained by this set of vehicles correspond exactly to those obtained with the set mentioned earlier.

Furthermore, vehicle B took up an almost radial position, in this case and also in the case where the axle originally had an oblique position (see fig. 51).

Trial arrangement for determining the transverse force liable to cause the derailment of an axle.

In order to determine the value of the transverse force causing derailment of an axle, a set of three vehicles was built to a scale of 1 : 5 actual size (see fig. 52). The two outer vehicles are two-axled and connected by a frame G and a yoke H.

TABLE XV.

Two axled vehicle. — Test axles braked.

nitial osition f test axle	Axle load	Brake block pressure		Guid. force	Frictional force	Co-effic. of friction	Slide (—) or Slip (+) after 5 turns of the wheels				Distance of the centre line of the track from the point	
			as % of wheel load				leading axle		rear axle		E	D
	N			K	P = 1.8 K	$f'' = \frac{P}{N}$	outer	inner	outer	inner	+tow. outside — tow. inside.	
—	kg	kg	—	kg	kg	—	mm	mm	mm	mm	mm	mm
0°	75	13	17.3	5.5	9.9	0.132	— 37	+ 5	— 32	+ 10	— 10	0
	75	22.5	30	5	9	0.12	— 46	— 4	— 48	— 6	— 10	0
	107	13	12.1	8.8	15.8	0.148	— 37	+ 5	— 37	+ 5	— 10	0
	107	22.5	21.1	7.5	13.5	0.126	— 39	+ 3	— 32	+ 10	— 10	0
	107	32.1	30	7.2	13	0.122	— 50	— 8	— 52	— 10	— 10	0
	139	13	9.4	11.9	21.4	0.154	— 40	+ 2	— 34	+ 8	— 10	0
	139	32.1	23.2	9.5	17.1	0.123	— 42	0	— 40	+ 2	— 10	0
	139	41.7	30	9.2	16.6	0.119	— 52	— 10	— 54	— 12	— 10	0
	171	13	7.6	15.2	27.4	0.160	— 35	+ 7	— 27	+ 15	— 10	0
	171	22.5	13.1	13.7	24.7	0.144	— 42	0	— 36	+ 6	— 10	0
	171	41.7	24.4	11.6	20.8	0.122	— 42	0	— 42	0	— 10	0
	171	51.3	30	11.6	20.8	0.122	— 52	— 10	— 57	— 15	— 10	0
° 30′	75	13	17.3	5.5	9.9	0.132	— 37	+ 5	— 30	+ 12	0	+14.4
	75	22.5	30	5	9	0.120	— 45	— 3	— 48	— 6	0	+14.4
	107	13	12.1	8.8	15.8	0.148	— 39	+ 3	— 35	+ 7	0	+14.4
	107	22.5	21.1	7.5	13.5	0.126	— 37	+ 5	— 32	+ 10	0	+14.4
	107	32.1	30	7.2	13	0.122	— 50	— 8	— 52	— 10	0	+14.4
	139	13	9.4	11.9	21.4	0.154	— 40	+ 2	— 37	+ 5	0	+14.4
	139	32.1	23.2	9.5	17.1	0.123	— 42	0	— 41	+ 1	0	+14.4
	139	41.7	30	9.2	16.6	0.119	— 52	— 10	— 54	— 12	0	+14.4
	171	13	7.6	15.2	27.4	0.160	— 37	+ 5	— 29	+ 11	0	+14.4
	171	22.5	13.1	13.7	24.7	0.144	— 42	0	— 38	+ 4	0	+14.4
	171	41.7	24.4	11.6	20.8	0.122	— 40	+ 2	— 42	0	0	+14.4
	171	51.3	30	11.6	20.8	0.122	— 52	— 10	— 58	— 16	0	+14.4
1°	75	13	17.3	5.5	9.9	0.132	— 38	+ 4	— 32	+ 10	+ 10	+28.8
	75	22.5	30	5	9	0.120	— 44	— 2	— 48	— 6	+ 10	+28.8
	107	13	12.1	8.8	15.8	0.148	— 38	+ 4	— 36	+ 8	+ 10	+28.8
	107	22.5	21.1	7.5	13.5	0.126	— 38	+ 4	— 33	+ 9	+ 10	+28.8
	107	32.1	30	7.2	13	0.122	— 50	— 8	— 52	— 10	+ 10	+28.8
	139	13	9.4	11.9	21.4	0.154	— 40	+ 2	— 38	+ 4	+ 10	+28.8
	139	32.1	23.2	9.5	17.1	0.123	— 40	+ 2	— 42	0	+ 10	+28.8
	139	41.7	30	9.2	16.6	0.119	— 52	— 10	— 54	— 12	+ 10	+28.8
	171	13	7.6	15.2	27.4	0.160	— 39	+ 3	— 30	+ 12	+ 10	+28.8
	171	22.5	13.1	13.7	24.7	0.144	— 40	+ 2	— 37	+ 5	+ 10	+28.8
	171	41.7	24.4	11.6	20.8	0.122	— 42	0	— 42	0	+ 10	+28.8
	171	51.3	30	11.6	20.8	0.122	— 53	— 11	— 60	— 18	+ 10	+28.8

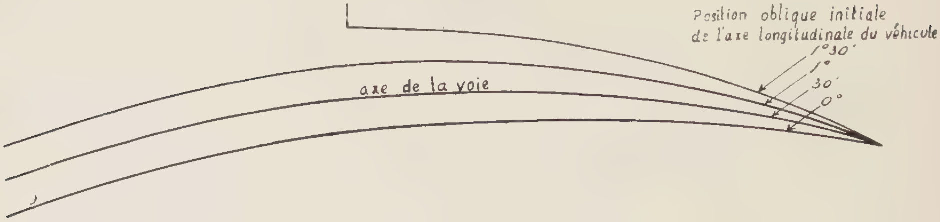


Fig. 51.

$$\text{Ratio } \frac{\text{longitudinal scale}}{\text{transverse scale}} = \frac{1}{8}$$

Fig. 51. — Two axled vehicle. Curve followed by point E (see fig. 47.)

Explanation of French terms :

Position oblique initiale de l'axe longitudinale du véhicule = Initial oblique position of the longitudinal axle of the vehicle. — Axe de la voie = Centre line of track.

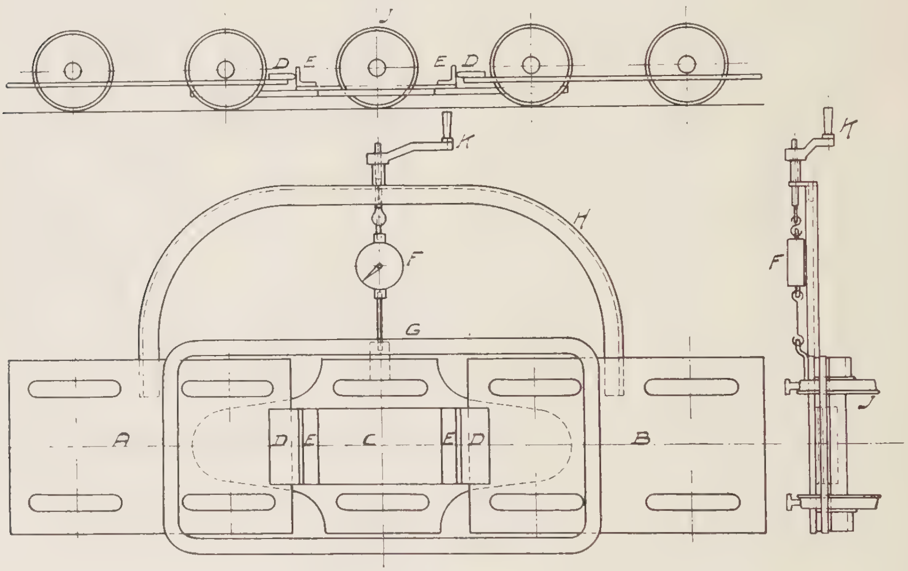


Fig. 52.

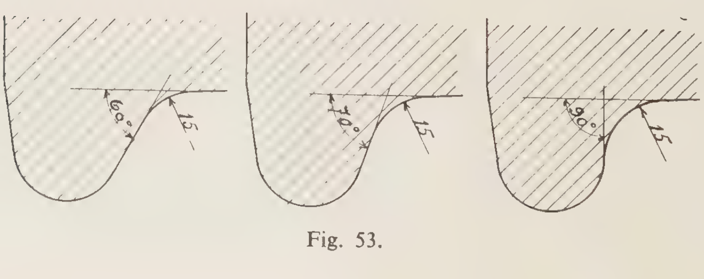


Fig. 53.

The middle vehicle C has one axle and can be displaced transversely. The direction of transverse displacement is determined by the slide links D and E which can be arranged in an oblique direction. The middle vehicle C can therefore be set in an oblique position in relation to the outer vehicles and displacement can be arranged to a particular angle. All the wheels have flanges reduced to a scale similar to that of the vehicle. Transverse displacement of the vehicle is by means of the crank K. The value of the force of transverse displacement can be measured by a dynamometer. The focal point of the force exercised on the middle vehicle is located at the level of the running surface of the rails.

The above mentioned set of vehicles

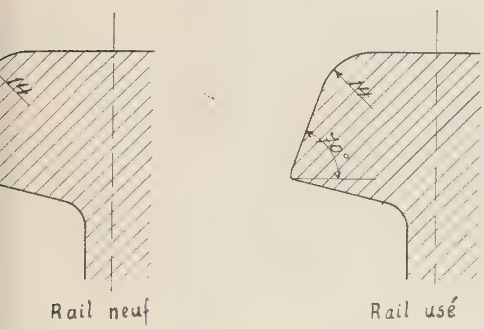


Fig. 54.

Explanation of French terms :

Rail neuf = New rail. — Rail usé = Worn rail.

was moved forward on an aligned road at a reduced speed (3 to 5 km/h) with various angles of bearing of the axle J of the middle vehicle. The trials were carried out with three different tyre profiles, i. e. the faces of the flanges were at 60°, 70° and 90° and with two rail profiles (new and worn) as shewn in figures 53 and 54. The load on the trial axle was applied on the two wheels and on the bearing wheel only. In the latter case the other wheel was completely free from loading.

The results obtained during these trials are shewn in Tables XIV and XV and are shewn graphically in figures 55 to 58.

From these results we note that :

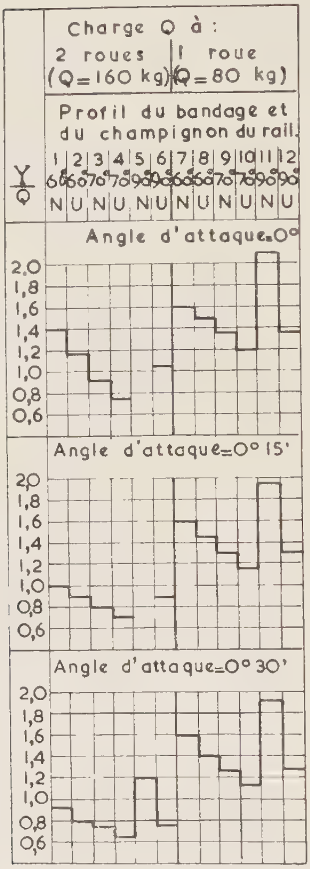
1. The transverse force Y, which causes derailment at the running speeds realised (3 to 5 km/h) depends on the tyre profile, the rail profile, the angle of bearing and the load on the rail.

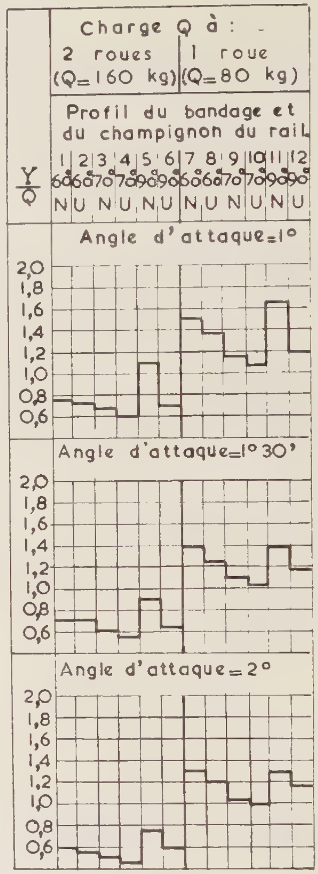
2. The ratio $\frac{Y}{Q}$ in the case of loading of the two wheels and rails with new profiles is located between 1.4 and 0.5 and for worn rails between 1 and 0.45, whilst in the case of loading the bearing wheel only and rails with new profiles the ratio is between 2 and 1 and with worn profiles between 1.5 and 1.

Briefly it is shewn that the ratio $\frac{Y}{Q}$ is less when two wheels are loaded than when a single wheel is loaded, that is to say, the transverse friction of the second wheel is active, tending to derailment. This is a practical demonstration of the thesis set out in the first part of this article.

3. The transverse force Y decreases and the risk of derailment increases for a greater angle of bearing.

4. In the case of rails with a new profile, a flange face angle of 90° is the most favourable, with 60° next and 70° as the most unfavourable, whilst in the case of worn rails the flange face angle of 60° is the best with 90° next and 70° as the most unfavourable.





N = rails neufs }
U = rails usés } voir les figures 53 et 54

Graph of ratio $\frac{Y}{Q}$ at which derailment occurs.

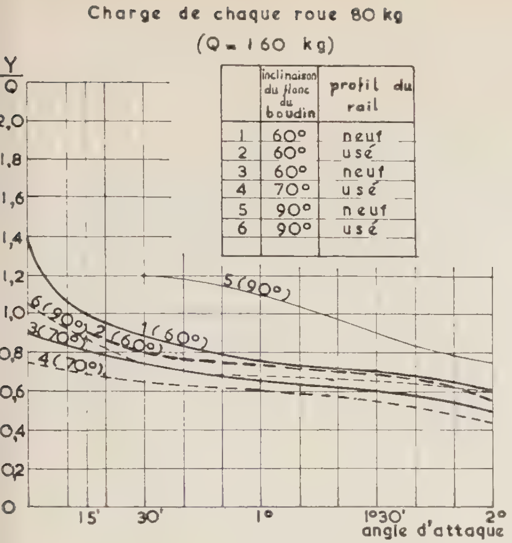
Fig. 55. Fig. 56.

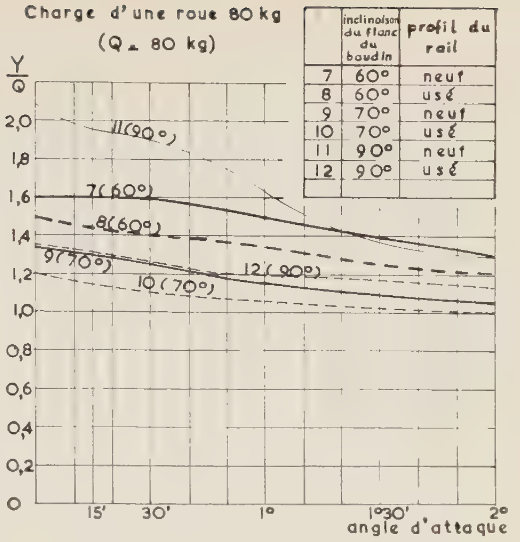
Explanation of French terms :

Charge Q à : 2 roues (Q = 160 kg), 1 roue (Q = 80 kg) = Load Q on 2 wheels (Q = 160 kg), 1 wheel (Q = 80 kg). — Profil du bandage et du champignon du rail = Profile of tyre and head of rail. — Angle d'attaque = Angle of bearing. — N = rails neufs = N = new rails. — U = rails usés = U = worn rails. — voir les figures 53 et 54 = See fig. 53 and 54.

5. The ratio $\frac{Y}{Q}$ in general decreases as the axle load increases.

The co-efficient of friction between wheel and rail f was determined for various rates of loading by displacing the full set of wheels transversely on the track. During these trials an average value of $f = 0.25$ was recorded.





Graph of risk of derailment at various ratios $\frac{Y}{Q}$ and different angles of bearing.

Fig. 57.

Explanation of French terms :

Charge de chaque roue 80 kg = Load on each wheel 80 kg. Inclinaison du flanc du boudin = Inclination of face of flange. — Profil du rail = Profile of rail. — Neuf = new. — Usé = worm. — Angle d'attaque = Angle of bearing.

Fig. 58.

Explanation of French tarms :

Charge d'une roue 80 kg = Load on one wheel 80 kg. — Inclinaison du flanc du boudin = Inclination of face of flange. — Profil du rail = Profile of rail. - Neuf = new. — Usé = worn. — Angle d'attaque = angle of bearing.

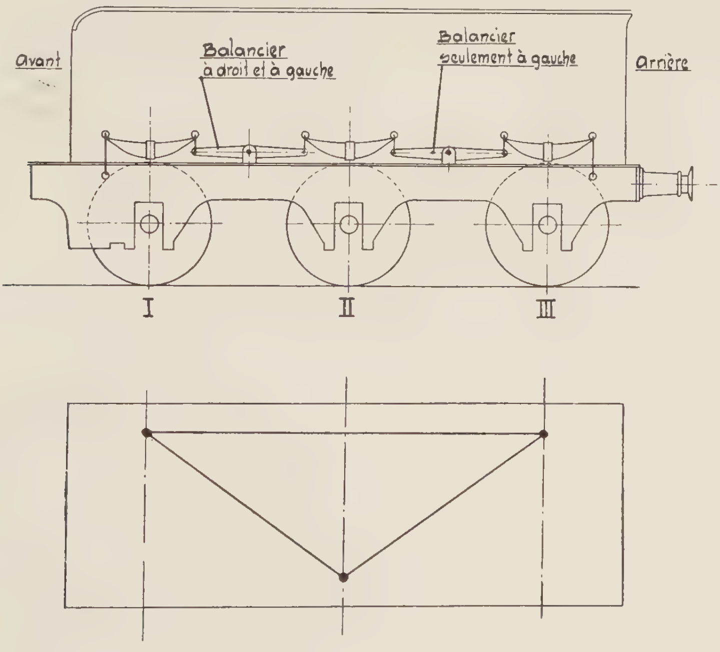


Fig. 59.

Explanation of French terms :

Avant = Front end. — Balancier à droite et à gauche = Equaliser, right and left. — Arrière = Rear end. — Balancier seulement à gauche = Equaliser, left only. — Schéma de la suspension = Diagram of suspension.

Full-scale trials with a three-axled tender to determine the transverse force of derailment.

In order to determine the value of the force K which must be exerted by the flange of a wheel bearing on the rail to cause this wheel to become derailed, trials were undertaken with a three-axled tender (see fig. 59). For the purposes of these trials, the middle axle was provided with transverse play by a suitable arrangement of the oil axleboxes and the horn slides and arranging the suspension arms so that they could take up the movement of the axleboxes. In addition, the axle could take up an oblique position up to an angle of 2°.

Equalisers were fitted between the suspension springs (two on the left-hand side and two on the right-hand side) so that the axle load could be fixed statically.

Trials were made with the tender empty and loaded.

Lateral force was applied by means of the arrangement in figure 60.

This comprised two discs, A and B, one of which bore on the wheel and the other on the rail. The discs were housed in the levers C and D, linked at each

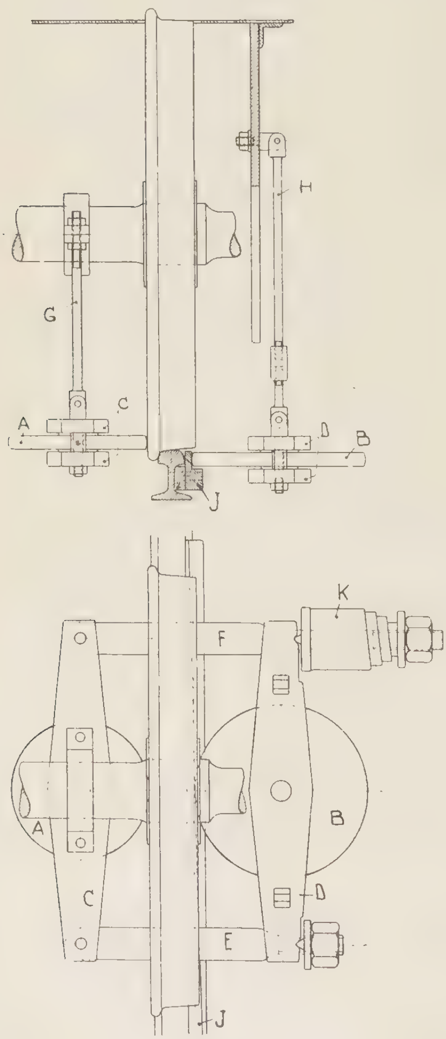


Fig. 60.

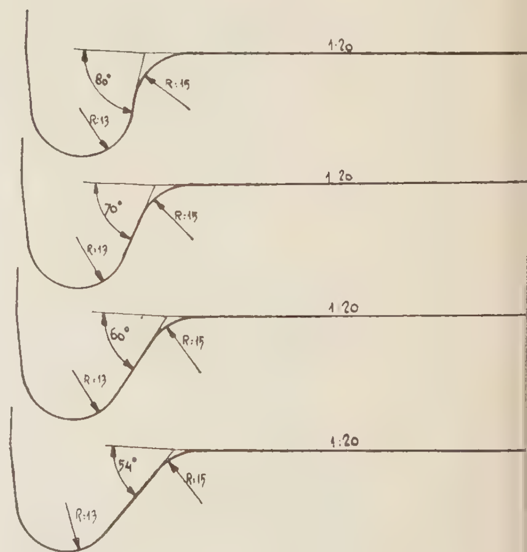


Fig. 61.

end by the bars E and F. A volute spring was also housed in the bar F. Levers C and D were suspended from and articulated with the rods G and H, rod G to the axle and rod H to the frame.

To the outer face of one of the wheels was fitted a packing piece J, shaped so that the disc B, running on this packing piece, could tension the spring K. The spring was calibrated so that a given amount of compression could be related to a certain force. The spring was then compressed until the resulting force caused the flange to mount the rail. At this moment, the value of the force was recorded and the value of the desired lateral force Y could thus be fixed.

These tests were carried out at a speed of about 5 km/h with tyre profiles having flange face angles of 54°, 60°, 70° and 80°, and with new, half-worn and fully worn rails as in figures 61 and 62 and also with angles of bearing of 30′, 1°, 1° 30′ and 2° and axle loads of 2 700 and 4 900 kg.

It may be remarked that the forces exerted by the two discs were not located in the same horizontal plane (difference in heights : 30 mm) and that, in these conditions, the pressures on the rail from the left and right-hand sides varied by about 2 %.

The results of these trials are shewn graphically in figures 63 and 64. They shew that the value of the ratio $\frac{Y}{Q}$ decreases :

a) as the angle of bearing increases;

b) with side wear of the rail head (very small only);

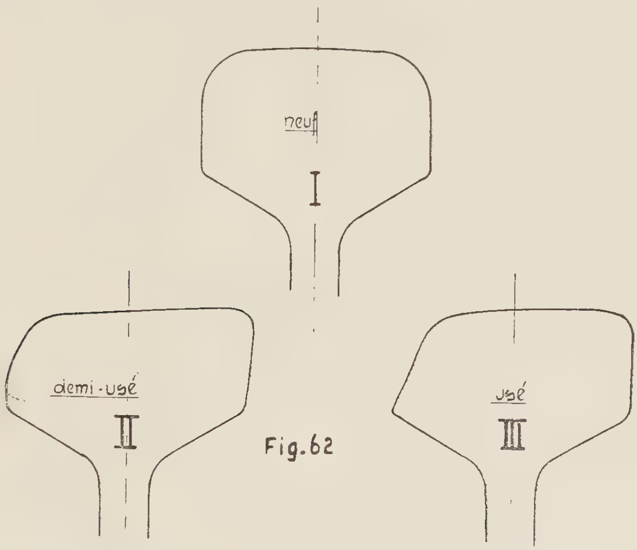


Fig. 62.

Explanation of French terms :

Neuf = New. — Demi-usé = Half worn. — Usé = Worn.

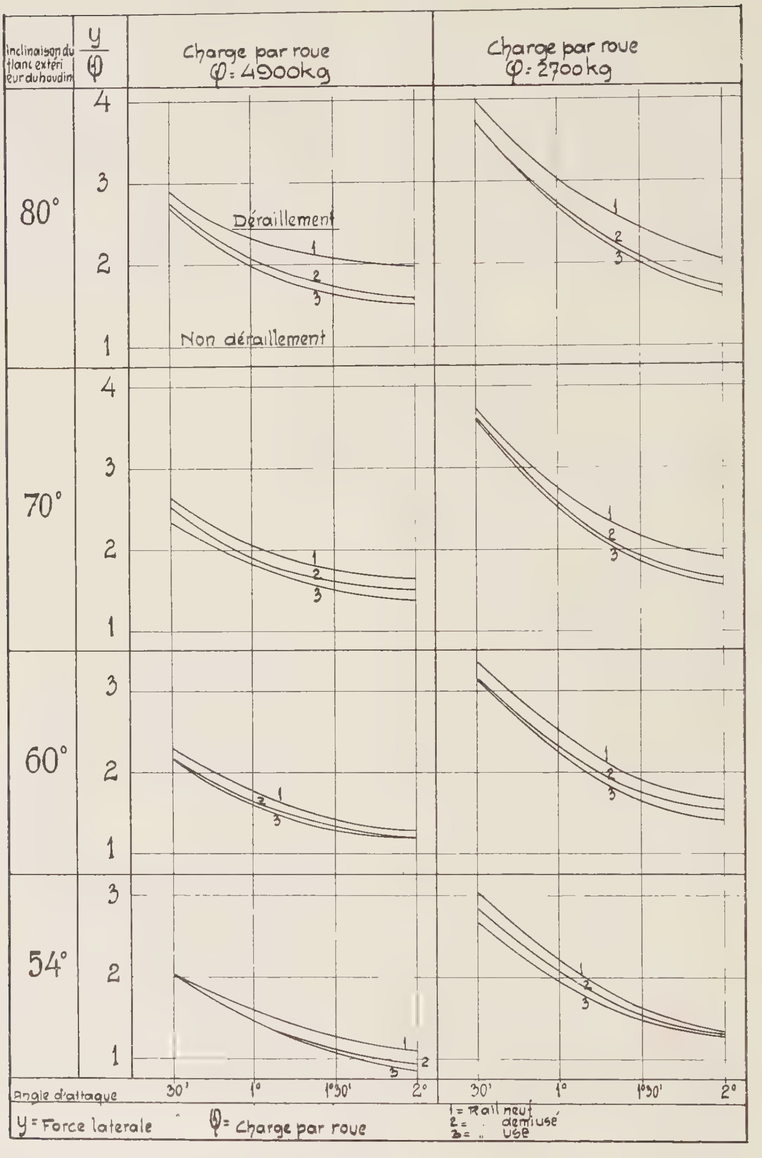


Fig. 63.

Explanation of French terms :

Inclinaison du flanc extérieur du boudin = Inclination of outer flange. — Charge par roue = Load per wheel. — Déraillement = Derailed. — Non déraillement = Not derailed. — Angle d'attaque = Angle of bearing. — Y = force latérale = Y = Lateral force. — Q = Charge par roue = Q = Wheel load. — 1. Rail neuf = 1. New rail. — 2. Rail demi-usé = 2. Half worn rail. — 3. Rail usé = 3. Worn rail.

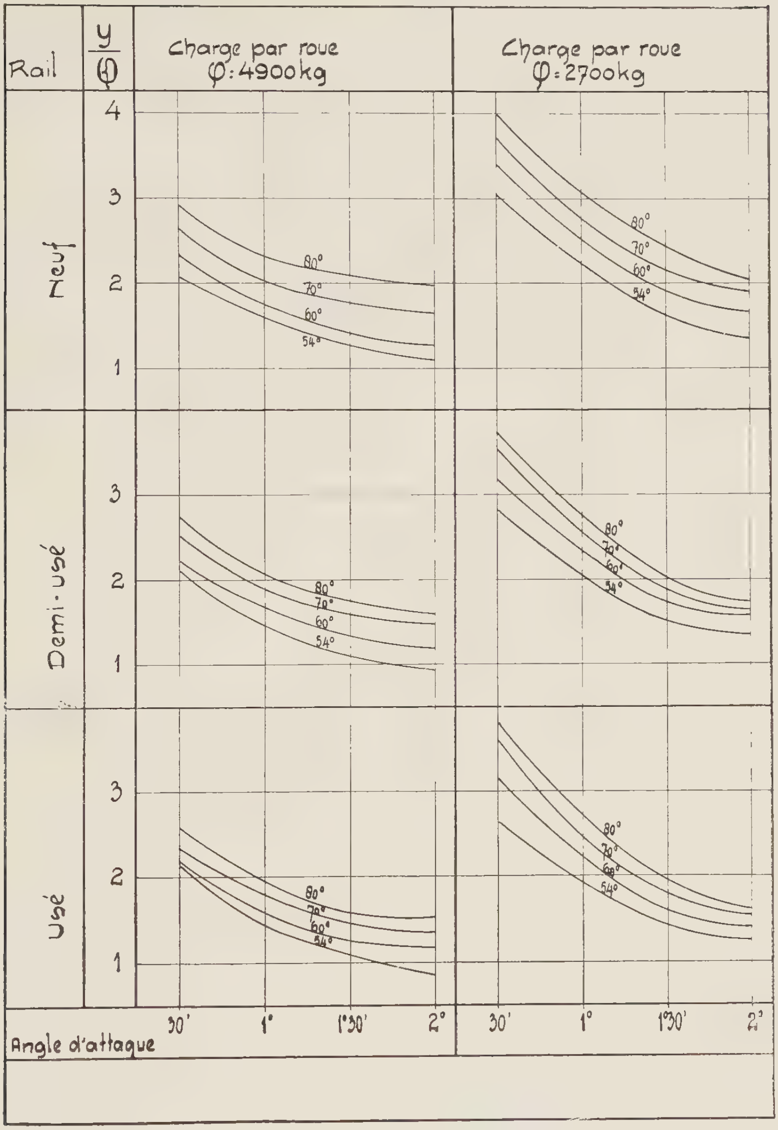


Fig. 64.

Explanation of French terms :

Rail = Rail. — Charge par roue = Wheel load. — Neuf = New. — Demi-usé = Half worn. — Usé = Worn. — Angle d'attaque = Angle of bearing.

c) with a reduced lateral angle of the flange;

d) as the wheel load increases.

It is worth pointing out that the force used not only forced the flange of one wheel over the rail, but also caused the transverse sliding of the other wheel on the rail.

It was not possible to force the flange over the rail with a bearing angle of 0°.

The co-efficient of friction, at rest, of the tyre on the rail reached a value of 0.35 during the trials.

1. a down gradient, designed to give the vehicle a certain speed. A speed of more than 60 km/h was reached;

2. a level section to serve for the derailment trials;

3. an up gradient, to destroy the kinetic energy of the vehicle.

The arrangement is shewn diagrammatically in figure 65. In carrying out the trials, the vehicle was run by gravity from the summit of the down gradient over the level section and the speed dissipated in running up the opposing

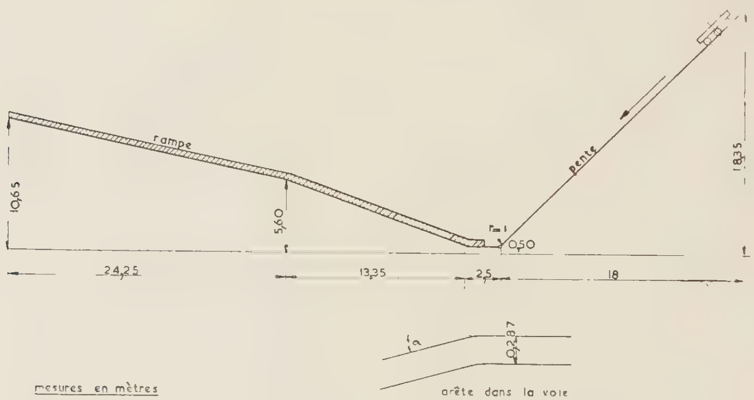


Fig. 65.

Explanation of French terms :

Rampe = Up gradient. = Pente = Down gradient. — Mesures en mètres = Measurements in metres. — Arête dans la voie = Bend in the track.

Trial arrangement for determining the risk of derailment at high speeds.

To enable consideration of the danger of derailment of a vehicle at high speed, a trial arrangement was constructed to a scale of 1 : 5, comprising a section of rail track on which a model vehicle ran at high speed.

The length of the track was divided into three parts, viz :

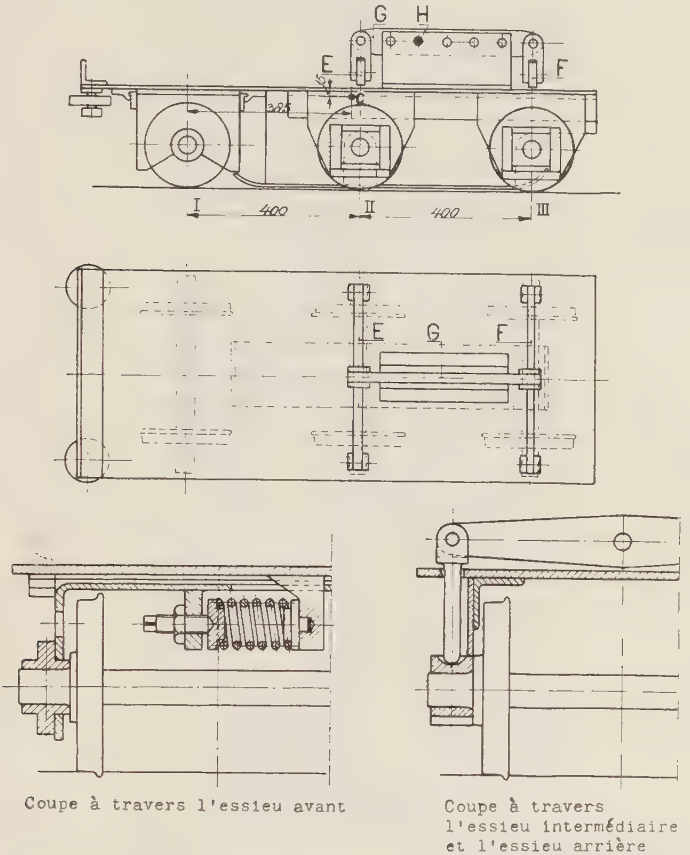
slope. To derail the vehicle on the level section, the track is here given a sharp bend against which the vehicle comes into contact with the rail at certain angle of bearing. For this purpose the track can be adjusted to give an angle of thrust up to 5°.

To determine the speed of the vehicle at the moment of derailment, a steel wire was run around a drum T located at the

top of the down-gradient. When the vehicle runs down this slope the drum is made to rotate by the wire. The speed of the vehicle is proportionate to the rotary speed of the drum; to establish the latter, the drum shaft is coupled to a locomotive speed indicator.

To prevent the vehicle falling off the installation after derailment on the level section, two wedges are fitted in front of a horizontal guiding disc, whilst on both sides of the up gradient protecting walls are erected to guide the derailed vehicle.

The vehicle was first built with two axles and later modified to three axles (see fig. 66) as it was difficult to load the



C = Centre of gravity of the vehicle.

Fig. 66.

Explanation of French terms :

Coupe à travers l'essieu avant = Section through leading axle. — Coupe à travers l'essieu intermédiaire et l'essieu arrière = Section through middle and trailing axles.

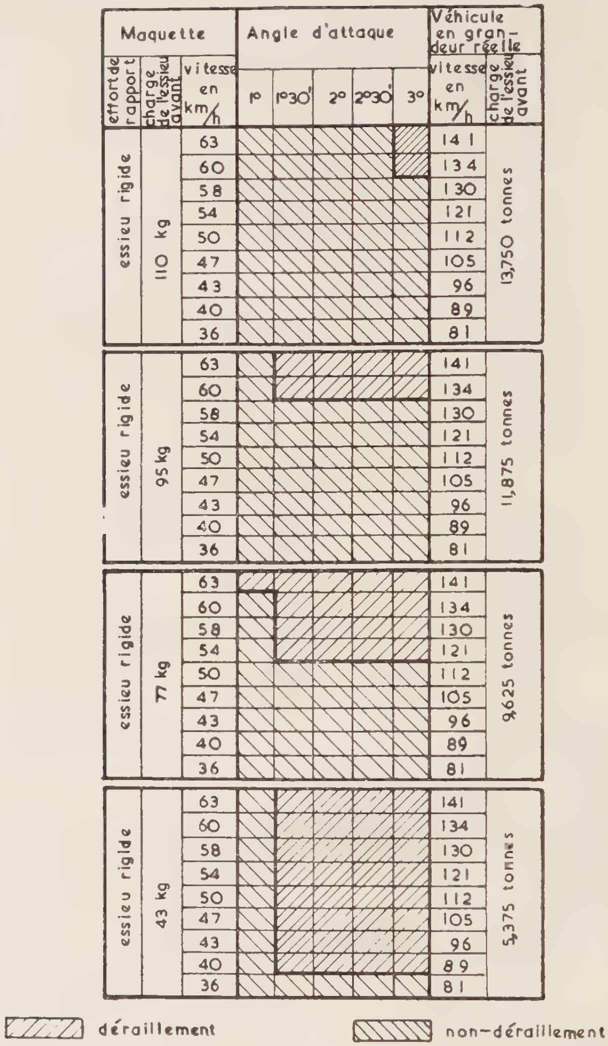


Fig. 67.

Explanation of French terms :

Maquette = Model. — Effort de rapport = Recoil effort. — Charge de l'essieu avant = Load on leading axle. — Vitesse en km/h = Speed km/h. — Angle d'attaque = Angle of bearing. — Véhicule en grandeur réelle = Full size vehicle. — Essieu rigide = Axle fixed. — Déraillement = Derailment. — Non- déraillement = No derailment.

leading axle sufficiently lightly to cause derailment.

The leading axle, which is the one intended for derailment, has a special housing in the frame of the vehicle, which can be displaced transversely and restored to a central position by means of a coil spring.

Maquette			Angle d'attaque					Véhicule en grandeur réelle	
effort de rappel	charge de l'essieu avant	vitesse en km/h	1°	1°30'	2°	2°30'	3°	vitesse en km/h	charge de l'essieu avant
50 kg	110 kg	63						141	13,750 tonnes
		60						134	
		58						130	
		54						121	
		50						112	
		47						105	
		43						96	
		40						89	
		36						81	
50 kg	95 kg	63		50	50	50	50	141	11,875 tonnes
		60		150	50	50	50	134	
		58		130	150	160	180	130	
		54						121	
		50						112	
		47						105	
		43						96	
		40						89	
		36						81	
50 kg	77 kg	63		50	50	50	50	141	9,625 tonnes
		60						134	
		58						130	
		54		50	50	50	50	121	
		50		105	125	135	160	112	
		47						105	
		43						96	
		40						89	
		36						81	
50 kg	43 kg	63		50	50	50	50	141	5,375 tonnes
		60						134	
		58						130	
		54						121	
		50						112	
		47						105	
		43		50	50	50	50	96	
		40		80	105	120	140	89	
		36						81	

déraillement   non-déraillement

The numbers shewn in the hatched portions are the maximum tensions of the return spring. *(For the explanation of the French words, please see fig. 67).*

Fig. 68.

The tension of the recoil spring is adjustable, whilst by making the housing rigid, the transverse movement can be completely eliminated so that the axle becomes rigid.

Transverse movement of the leading axle is recorded, which allows, except in the case of momentary shock, the force with which the axle is thrust transversely to be deduced, and the bearing force of

Maquette			Angle d'attaque					Véhicule en grandeur réelle	
effort de rappel	charge de l'essieu avant	vitesse en km/h	1°	1°30'	2°	2°30'	3°	vitesse en km/h	charge de l'essieu avant
100 kg	110 kg	63						141	13,750 tonnes
		60						134	
		58						130	
		54						121	
		50						112	
		47						105	
		43						96	
		40						89	
		36						81	
100 kg	95 kg	63		100	100	100	100	141	11,875 tonnes
		60			100	100	100	134	
		58		160	185	210	220	130	
		54		145	175	185	200	121	
		50		130	160	170	190	112	
		47						105	
		43		115	130	145	160	96	
		40						89	
		36		110	120	130	140	81	
100 kg	77 kg	63		100	100	100	100	141	9,625 tonnes
		60		100	100	100	100	134	
		58		100	100	100	100	130	
		54		100	100	100	100	121	
		50		150	160	165	200	112	
		47						105	
		43		130	140	150	170	96	
		40						89	
		36		115	125	130	140	81	
100 kg	43 kg	63		100	100	100	100	141	5,375 tonnes
		60						134	
		58						130	
		54						121	
		50						112	
		47						105	
		43		100	100	100	100	96	
		40		135	145	150	100	89	
		36		120	125	135	150	84	

déraillement

non-déraillement.

The numbers shewn in the hatched portions are the maximum tensions of the return spring. *(For the explanation of the French words, please see fig. 67).*

Fig. 69.

the axle against the rail to be determined, at least in total.

The intermediate and rear axles have a transverse equaliser. The two transverse equalisers are in turn conjugated by a longitudinal equaliser with variable transmission, so that constant distribution of the wheel load is ensured for any initial position whatsoever (load fixed statically).

Under the vehicle is fitted a wooden

slide, which moves on a wooden plank fitted on the track centre line of the up gradient and by which the vehicle is braked to a stand. Whilst running up the gradient, the vehicle is lifted slightly, so that the wheels are no longer in contact with the rails.

The friction of the wheels in rotation is thus changed to the plain sliding friction of the wooden skids. By means of this device the height of the up gradient is kept to a minimum and the vehicle does not run back from the highest position reached.

To determine whether the vehicle is derailed, which it is not possible to do visually owing to the high speed of the vehicle, a recording device has been provided above the position where derailment can be produced. By means of this a line is traced on a paper band fixed to the vehicle to provide a record of its exact behaviour.

The principal dimensions of the three-axled vehicle are as follows :

Gauge of track	287 mm
Lateral play of axle in track . .	2.2 mm
Weight of leading set of wheels, including the housing for lateral displacement	42 kg
Weight of each set of wheels .	18.5 kg
Total weight of vehicle	265 kg
Moment of inertia due to the mass, in relation to the centre of gravity around :	
longitudinal axis	65 cm kg/sec^2
transverse axis	321 cm kg/sec^2
vertical axis	365 cm kg/sec^2
Return spring :	
average diameter of coils. . .	53.5 mm
diameter of section of metal. .	9.5 mm
free length.	82 mm
number of coils	5 1/2
specified compression	1 mm/10 kg

The moments of intertia were calculated from torsion-oscillation trials of the « Karlsruhe » type.

TABLE XVI.

Case	Load on the rails per axle, in kg			
	Leading	Intermed.	Rear	Total
A	115	54	96	265
B	101	82	82	265
C	83	116	66	265
D	49	183	33	265

Cases A-D refer to the distribution of load by movement of the articulating pivot of the longitudinal equaliser.

The results of these trials with the 1 : 5 scale model vehicle were converted ma-

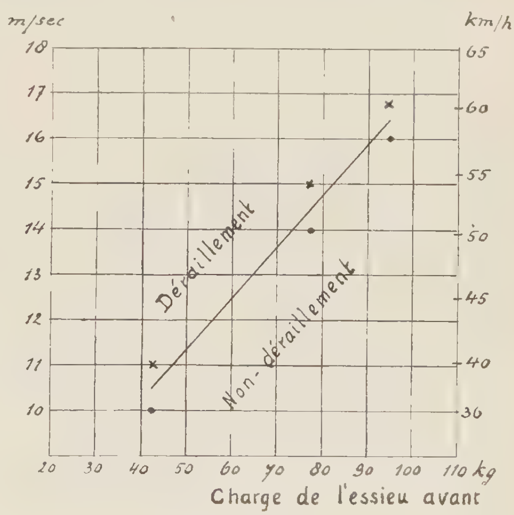


Fig. 70.

Explanation of French terms :

Déraillement. — Déraílment. — Non-déraillement. = No derailment. — Charge de l'essieu avant = Load on leading axle.

thematically to those for a full size vehicle and are given in figures 67 to 69, whilst figure 70 shews, for the model, the risk of derailment in relation to the speed and load of the leading axle and figure 71, in relation to the angle of bearing and the speed.

We may now designate the dimensions of the full-size vehicle by capital letters and the corresponding dimensions of the model vehicle by small letters, i. e. :

length : L and l;

mass : M and m;

weight : P and p;

time : T and t;

speed : V and v;

acceleration : A and a;

moment of inertia of the mass : I and i.

Taking the linear dimensions of the vehicle in full size as n times that of the smaller vehicle, the mass and weight

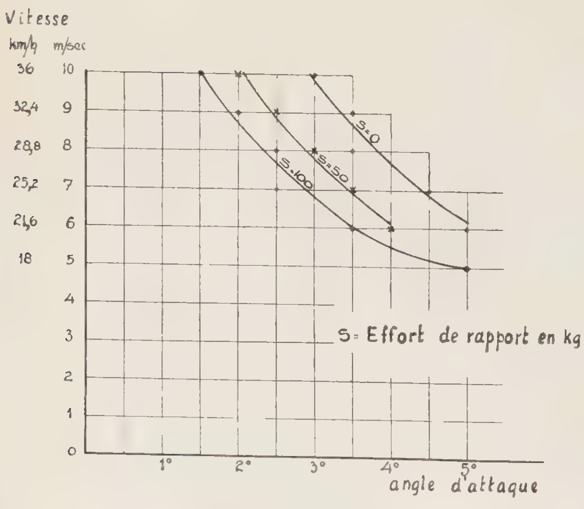


Fig. 71.

Explanation of French terms :

Vitesse = Speed. — Effort de rapport en kg = Recoil effort in kg. — Angle d'attaque = Angle of bearing.

dimensions will be n^3 times that of the model, or :

$$L = nl, \; M = n^3 m \text{ and } P = n^3 p$$

We have :

$$p = m \; a \qquad P = M \; A$$

or :

$$n^3 p = n^3 \; m \; A$$

$$p = m \; A$$

then

$$a = A$$

$$a = \frac{l}{t^2} \qquad A = \frac{L}{T^2} = \frac{nl}{T^2}$$

therefore :

$$\frac{l}{t^2} = \frac{nl}{T^2}$$

or :

$$T^2 = nt^2$$

$$T = t\sqrt{n}$$

$$v = \frac{l}{t}, \qquad \frac{V}{T} = \frac{nl}{t\sqrt{n}}$$

or :

$$V = v\sqrt{n}$$

$$i = m \; l^2$$

$$I = M \; L^2 = n^3 \; m \; n^2 \; l^2 = n^5 \; m \; l^2$$

or :

$$I = n^5 \; i$$

If the linear dimensions of the full size vehicle are n times those of the model, the scale shewn in Table XVII may be used.

TABLE XVII.

Dimension	Ratio $\frac{\text{Full size vehicle}}{\text{Model}}$
Length	n
Mass	n^3
Weight (force)	n^3
Time	$\sqrt{n}$
Speed	$\sqrt{n}$
Acceleration	1
Moment of inertia due to the mass	n^5

From the results obtained with the model vehicle, it can be concluded that :

1. The risk of derailment does not depend on the degree of transverse resilience (centring force) of the leading axle and the angle of bearing (up to 3°) but only on the axle load and speed. It may be remarked that the centre of gravity of the vehicle being located above the level of the point of bearing of the leading axle on the rail, one of the wheels is overloaded and the other under-loaded at the moment of contact.

2. No derailment is produced with an angle of bearing of 1° or less.

3. The relationship between the load on the leading axle and speed at which derailment occurs, is shewn above a certain speed (38 km/h for the model, 85 km/h for the full-size vehicle), as an approximately straight line. The relationship can be expressed in the following formula :

For the model :

$V = 0.41\ Q + 20.1$ (see fig. 70) and for the full-size vehicle : $V = 6\ Q + 60$ (see fig. 72) : where V = speed in km/h, above which derailment will occur : Q = load on the leading axle (two wheels) at rest, for the model in kg, for the full-size vehicle in tons.

4. In the case of derailment, the tension of the return spring does not increase. This fact must be explained by the momentary duration of the action of the force.

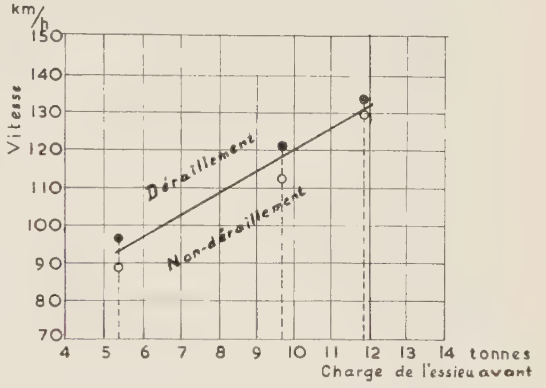


Fig. 72.

Explanation of French terms :

Vitesse = Speed. — Déraillement = Derailment. — Non-déraillement. — No derailment. — Charge de l'essieu avant = Load on leading axle.

5. In the case of non-derailment, the tension of the spring increases with the speed and the load.

Figure 72 is a reproduction of figure 70, applicable to a full-size vehicle.

[**621** .135 .2 & **625** .214]

Advantages of abundant lubrication in plain bearings,

by M. F. HENRION,

Ingénieur civil A. I. Lg.

In an article entitled « Mechanical technique of lubrication » which appeared in the *Revue de l'Industrie Minérale* for June 1948, M. Paul MARTINET, consulting engineer to the « Société des Forges et Aciéries de la Marine », drew attention to some interesting features of the utilisation of plain bearings.

Apart from the question of price, ease of supply or maintenance, and other hard economic facts, the advantages may be summarised as follows :

Bearing brasses designed in accordance with the mechanical principles of good lubrication technique are capable of carrying much heavier loads than those permissible in a ball or roller bearing.

Without appreciable wear, and using ordinary machine oil, they run with a notably lower coefficient of friction than that obtained in a ball or roller bearing operating under similar conditions and requiring the use of a special grease.

There is however, one point that has not yet received sufficient attention, namely the *importance* attaching to an *abundant* supply of oil, flooding the rubbing surfaces, and its favourable repercussions upon the utilisation of journal bearings, particularly for heavy loads and high speeds.

This point will be discussed in the present article which deals more particularly with the lubrication of the journals of axles in railway rolling stock. The discussion leads to useful conclusions concerning the numerous industrial applications of journal bearings, as for instance in machine tools, rolling mills, etc...

***

PART ONE.

GENERAL CONSIDERATIONS.

When two metallic surfaces rotate relatively to each other and are separated by a lubricating film of sufficient thickness, constantly renewed so as to maintain that thickness, the resultant coefficient of friction derives less from the action of the surfaces than from *viscous* flow within the *fluid layer itself*, i. e. lamellar jamming and gliding under pressure which has come to be known as hydrodynamic lubrication (1).

(1) Some writers have sought to explain this internal movement of the fluid not by the relative gliding of the lamellae of oil relatively to one another but by the rubbing action of molecules of oil, infinitely small, rolling upon each other (like so many balls or rollers), and which in their entirety constitute the lubricating layer separating the two metallic surfaces.

If the thickness of the film is reduced to such an extent that the rubbing surfaces, or rather the asperities produced by machining, come into contact at one or more points, perforation ensues. The film breaks down, the oil clings to the metal by molecular attraction alone and the condition of the metallic surfaces becomes the preponderating factor. We are no longer considering viscous lubrication, but *boundary* lubrication. From this stage onward, wear commences and may be followed by the well known phenomena, first of overheating and finally, of seizure.

Between these two states of *hydrodynamic* lubrication and *boundary* lubrication, there exists a critical point corresponding to the commencement of rupture of the continuity of the lubricating film.

***

Under conditions of *boundary* lubrication, the factor of first importance is the degree of finish of the metallic surfaces.

In the case of *hydrodynamic* lubrication, the factor that ensures a low and consequently safe value of the coefficient of friction is the thickness of the oil film. It is clear therefore that the continuity and stability of the film and its resistance to breakdown, either sudden or progressive, will be all the greater when the oil supply is abundant.

When starting from rest, an abundance of oil promotes the speedy formation of a thick film. This advantage becomes increasingly apparent at high speeds since the intense oil circulation prevents any undue rise of temperature, maintains the viscosity of the oil and so precludes overheating [1]. These favourable conditions are most readily seen when, as in the case of axleboxes provided with mechanical lubrication, the rate of feed increases at the same time as the speed of rotation of the journal.

Finally, it should be remembered that the greatest danger to the film, whereby it may become perilously thin or even break down, lies in heavy loads and the consequently greater shocks transmitted to the journal, particularly at high speeds.

***

M. MACKEE and Professor HANOCQ, the latter at the Laboratory of the University of Liège, have both shown conclusively that, *in lubrication, what matters most is the quantity of oil drawn on to the bearing, which must be sufficient under all conditions to ensure the formation and maintenance of the oil film.*

***

When starting from rest, it is essential, in order that the oil film may build up without delay, that the journal should pick up the quantity of oil necessary for the formation of the film as soon as it starts to rotate. This will not be possible unless there remains, when at rest, an appreciable quantity of oil stored in the oil grooves of the bearing brass or in the channel that exists between the journal and the brass, formed by the clearance machined on the latter.

---

(1) The viscosity of the oils commonly used for lubrication decreases very rapidly with rising temperature. With the commencement of overheating the viscosity falls sharply away and the rate of heating is correspondingly intensified.

Such a reserve can only accumulate if the journal is coated with a certain thickness of lubricant while running and if in addition the oil is possessed of sufficient viscosity, that is to say, that its temperature has remained normal.

Axleboxes that are lubricated by a pad or by packing cannot fulfill these conditions. The coating of oil to be found on the journal when starting is extremely thin, the supply of lubricant, under normal weather conditions, being insufficient to provide the required reserve, and the suction when starting up not being instantaneous.

Moreover, recent experiments have shown that in cold weather the capillary flow of oil through the wicks is notably diminished. At zero centigrade, it is practically nil (1). It follows that in winter, boxes fitted with lubricator pads or packing will only deliver oil after the journal, the brass, the body of the box and the oil itself have progressively warmed up. This will evidently take an appreciable time (2).

On the other hand, in axleboxes provided with mechanical lubrication the journal is flooded with lubricant while running, which permits machining the brass with a large clearance with respect to the journal and calls for brasses suitably furnished with numerous wide oil grooves (1). These two features together provide the reserve oil pockets necessary for starting up.

Furthermore, in mechanically lubricated boxes the distributing mechanism is not influenced by variations of temperature and the quantity of oil bathing the journal is, even when starting up, independent of atmospheric conditions.

***

What are the factors that may initiate rupture of the oil film *while running?*

They are :

a) instantaneous peak loading due to shock;

b) increased speed, when this is not accompanied by a sufficient increase in the rate of oil feed.

In the first case, it is essential that as soon as the effect of the abrupt overload causing discontinuity of the film has disappeared, the film should instantly reform. The case is analogous to that met with when starting up. As previously stated, the film will not immediately reform unless the internal oilways in the brass and the channel provided by the clearance between brass and journal together comprise a reserve or a cushion of oil due tot the excess supply. The film will thicken as soon as an abundance of lubricant arrives.

So far as the second factor is concerned,

(1) See the interesting tests concerning this, described by Mr. Paul Martinet in the journal *L'Usine Nouvelle*. dated March 17, 1949.

(2) The repetition of this delay in lubrication, after each stop, accounts for the considerable wear of journals and brasses in boxes fitted with pads.

(1) It is in fact essential that the whole of the copious oil supply delivered to the brass should reach the journal undiminished; whence the necessity for mechanically lubricated boxes to incorporate well designed brasses having generous oil pockets and appropriate distributing channels.

it has been demonstrated that the thickness of the film increases with the speed. It is understood that the rate of oil feed must be correspondingly greater as the film increases in thickness, hence the need for a lubricating mechanism that feeds the brass faster with increasing speed of the vehicles. (This cannot be achieved at high speeds by constant feed arrangements such as packing or lubricator pads.)

Finally, in a mechanically lubricated axlebox, the flooding of the journal prevents temperature rise, enables the lubricant to maintain its viscosity and precludes all danger of overheating. It is maintained by virtue of the constant renewal of oil that has been cooled by vigorous circulation in contact with the walls of the box, the shell of which is of appropriate shape and is kept cool by the flow of the outer air.

***

It should be noted that when abundant lubrication is provided the calculation of journal sizes requires fresh consideration since the problem of extracting heat units from the axlebox assumes a different form.

Since lubricator pads cannot create sufficient oil circulation to deal with the calories produced by friction, it is necessary that the journal and brass should offer the greatest possible area of metallic surface in contact with the oil. For this reason, the chosen dimensions are in many cases greater than would be indicated by considerations of mechanical strength alone. If on the other hand, the amount of oil circulating — and consequently bathing the journal — is sufficient to ensure that the calories are entirely dissipated at the external surfaces of the box, mechanical requirements alone will determine the length and diameter of the journal which may thus be reduced.

The following advantages then result :

— Reduction in the dimensions of the journal and therefore in the cost of the axle;

— Consequent reduction in size and cost of axleboxes;

— Reduction of unsprung weight;

— Smaller deflection of the journal as the result of its reduced length;

— Possible increase in the size of the journal collar in view of the intensified lubrication, resulting in reduction of end wear on bearing brasses;

— Improvement of the coefficient of friction (1).

***

M. HAGUENAUER, President of the Rolling Stock Commission of the S. N. C. F., had already pointed out in one of the last pre-war issues of *Transports Modernes* the advantages of mechanical lubrication *in ensuring an abundant oil circulation and the intensive dissipation of calories.*

***

PART TWO.

CONCRETE EXAMPLES.

The following examples show clearly that the results obtained in practice

(1) In an article entitled « Experiments on bearings and study of the improvement of films », which appeared in *Machines et Métaux* in August 1948, M. Martinet showed that : a reduction in the length of the journal reduced friction considerably and, in addition, that increased speed resulted in thickening of the film and by virtue of this effect lowered the coefficient of friction.

confirm the calculations and illustrate the advantages indicated above.

***

A. — Comparison between boxes fitted with mechanical lubrication and with lubricator pads, running under an express coach.

1° *Results of the trial.*

The trial was carried out, before the war, with a special train running over the route Paris-Les Aubrais (South Eastern Region of the S. N. C. F.), taking 57 minutes for the journey at an average speed of 123 km/hour (77 m.p.h.) with a spurt at 150 km/h (94 m.p.h.) for 14 minutes between Monnerville and Boisseaux. The bogies were fitted partly with boxes using lubricator pads and partly with mechanically lubricated boxes.

The conditions of load, speed and ambiant temperature were similar for the two types of boxes and the temperatures recorded at the end of the journey were as follows :

35° C for the mechanically lubricated boxes;

110° C for the boxes with lubricator pads.

At these temperatures the absolute viscosity of the oil constituting the film is as given below :

35° C — 0.016 kg sec/m^2;

110° C — 0.0008 kg sec/m^2.

While it is not possible to make direct use of these figures (particulars of the loads and the values of the coefficient of friction being unknown) a complete set of sufficiently conclusive data may be obtained by referring the temperature readings to others obtained in the laboratory.

During trials of a *box fitted with pads* and loaded with 7 000 kg (6.9 tons) the coefficient of friction was 0.0047 and the temperature of the bearing in the *absence* of ventilation was 137° C.

By contrast, during another laboratory trial of a *mechanically lubricated box*, loaded as before with 7 000 kg and *unventilated*, the temperature was 47° C and the coefficient of friction only 0.0011.

If in these two cases ventilation had been provided the temperatures of 137° and 47° would have been lowered and comparison with those recorded during the service trials previoulsy mentioned is permissible.

It appears possible without risk of serious error to base an argument upon the following data :

Box with lubricator pad :

load : 7 000 kg;

average speed at surface of journal : 5 m/sec;

temperature of bearing : 110° C;

viscosity of oil in the film : 0.0008 kg sec/m^2;

width of rubbing surface : 70 mm;

coefficient of friction : 0.0047.

Box with mechanical lubrication :

load : 7 000 kg;

average speed at surface of journal : 5 m/sec;

temperature of bearing : 35° C;

viscosity of oil in the film : 0.016 kg sec/m^2;

width of rubbing surface : 30 mm;
coefficient of friction : 0.0011.

***

2° *Theoretical discussion of the trial.*

The performance of the box with lubricator pad is undeniably bad. To begin with, it operates under conditions of *boundary* lubrication; but worse still, since the oil circulation is not sufficiently vigorous to prevent the temperature from rising, the viscosity diminishes to such an extent that it is no longer possible under such conditions to maintain an oil film capable of preventing some pick-up of whitemetal. This does in fact occur. Under the load of 7 000 kg the breadth of the zone of contact where the metal has yielded is about 70 mm (2 3/4 inches) for the pad-lubricated bearing and 30 mm (1 3/16 inches) for the other one.

The brasses in each box were new, and had been machined with a diametral clearance of 3 mm.

***

It is possible to calculate approximately the viscosity, and hence the temperature of the oil, for a film thickness of 0.006 mm (.00024 inch) which is *essential* for safe running under conditions of « hydrodynamic friction », by applying the formula for hydrodynamic operation :

$$F = fQ = \frac{\mu SV}{h} \qquad \text{(A)}$$

in which :

F = total friction, in dynes;
f = coefficient of friction;
Q = load, in dynes;
μ = viscosity of oil, in poises;
S = rubbing area, in cm^2;
V = speed of relative displacement of the surfaces in cm/second;
h = thickness of oil film in cm.

Putting $f = 0.0015$, which is an average value for the coefficient of friction when running just within the hydrodynamic range, assuming a width of 30 mm for the rubbing surface over a parallel-sided zone 300 mm (11 3/4 inches) long and taking the film thickness in this zone at 0.006 mm we obtain :

$$\mu = \frac{f\,Qh}{SV}$$

$$= \frac{0.0015 \times (7\,000 \times 981\,000) \times 0.0006}{90 \times 500}$$

$$= 0.14 \text{ poise.}$$

This value for the viscosity corresponds, for the oil used in these trials, to a temperature of 72° C, which would appear to be the *limiting safe* temperature.

***

The foregoing shows that :

a) By virtue of its intense oil circulation a mechanically lubricated axlebox will run at temperatures well below 72° C, and will keep within the *hydrodynamic* friction range under the most severe working conditions in respect of loads and speeds;

b) An axlebox lubricated by a pad or by packing will normally run at temperatures above 72° C, and does not offer, under heavy duty, a sufficient margin of security. It has been shown (page 443) how, when starting from rest or in cold

weather this margin is illusory, the suction diminishing rapidly as the temperature falls and tending to fail completely at zero Centigrade (quite apart from the fouling of the pad, the necessity for topping up with oil (1), and so on).

***

B. — Comparison of running conditions in a mechanically lubricated box at different speeds.

It can be shown by calculation equally well as by practical trial that an increase in speed from 100 km/h (63 m.p.h.) to 150 km/h (94 m.p.h.) has little influence upon the temperature of a box of this type, or on that of the oil or of the bearing, and in consequence little influence upon the state of the oil film or the *safety* of the box. This is the result of abundant lubrication.

1° *Results of trials.*

At the time of the trials over the Paris-Les Aubrais route, it was noted that at 125 km/h (78 m.p.h.) the oil temperature was appreciably lower than at 100 km/h (63 m.p.h.), allowing for air speed. The temperatures recorded in the bearing and the journal were slightly higher, but the difference was not of a sufficiently high order to warrant attention.

2° *Theoretical discussion.*

Formula A (page 446) shows that the total friction, other factors remaining equal, is proportional to the speed and hence to the amount of heat to be dissipated.

Now the loss of heat by convention from the box to the surrounding air is defined by :

$$Q = K\,S\,(t - t')\,h$$

and is proportional to K, which is itself proportional to $V^{0.7}$ approximately, V being the air speed in m/sec.

For $V = 27.6$ (90.5 feet/sec) we have $V^{0.7} = 14.3$ (47 feet/sec);

and for $V = 41.5$ (136 feet/sec) we have $V^{0.7} = 19.8$ (65 feet/sec).

If in passing from 100 to 150 km/h (63 to 94 m.p.h.) the heat transmission from the rubbing surfaces is favourably influenced by the circulating oil, the temperatures should as a result of this alone be modified in the proportion of, say, 1 to 0.9.

Thus, considering all factors, we have :

$$\frac{\text{Temperature at 100 km}}{\text{Temperature at 150 km}} \times \frac{100}{150} \times \frac{19.8}{14.3}$$

$$\times \frac{1}{0.9} = \frac{1980}{1940} = 1 \text{ approximately.}$$

In other words, the temperature of the oil will not vary in proportion to the speed, its viscosity will be maintained and lubrication will be completely assured.

***

These two estimates, the one eminently practical and the other theoretical, tally completely and show that hydrodynamic lubrication together with *accelerated* oil circulation will ensure complete safety at the highest speeds that can at present be foreseen.

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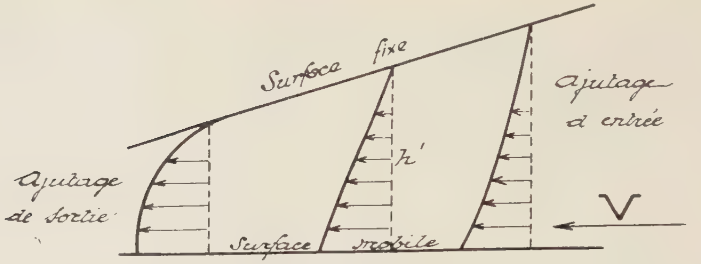
(1) It has been proved that the suction becomes increasingly unreliable as the oil level falls i. e. with increasing length of worsted exposed.



Geometrical loci of the extremities of the vectors. Speeds of the different elements of the oil film in one and the same section of the film.

Fig. 1.

Explanation of French terms :

Ajutage de sortie = Outlet nozzle. — Ajutage d'entrée = Inlet nozzle. — Surface mobile = Movable surface. — Surface fixe. = Stationary surface.

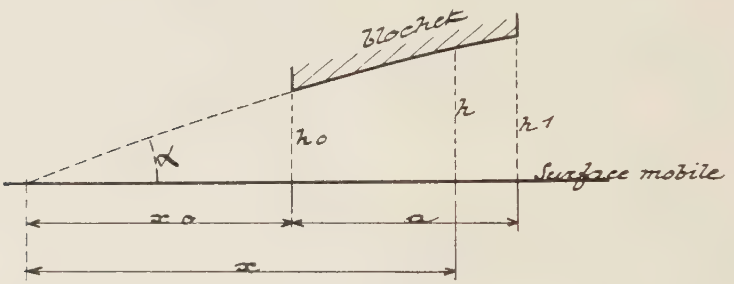


Fig. 2.

Explanation of French terms :

Blochet = Block. — Surface mobile = Movable surface.

C. — Safety of mechanically lubricated boxes under heavy loads.

The favourable influence of abundant oil circulation upon the safety of axle-boxes under heavy loads may be analysed theoretically in the following manner :

It is known that the basic differential equation for hydrodynamic lubrication for the case of the block (Reynolds equation) may be written :

$$\frac{dp}{dx} = \frac{6 \mu V (h - h')}{h^3}$$

In this formula (Fig. 1) :

p is the pressure within the oil film at a point defined by the abscissa x;

μ is the viscosity of the oil;

V is the linear speed of relative displacement of the surfaces under consideration;

h is the height of the oil film at a section denoted by the value of x;

h' is the height of the film at a section where the parabola of the speeds of the different molecules becomes a straight line, that is to say where the speed of the various molecules varies from the moving surface to the immobile surface according to a linear law.

In Fig. 2 :

$$m = \frac{h_1 - h_o}{h_o}$$

where h_1 is the height of the oil film at the point of entry, h_0 the height at the exit, and :

$$h = h_o + \text{tg}\ \alpha\ (x - x_o)$$

Substituting these values and integrating, we obtain the following value for the maximum pressure (1) :

$$P_{max} = \frac{3}{2} \frac{m}{(m+1)(m+2)} \frac{\mu\ V_a}{h_o^2}$$

This result may be extended to cover the case of the *partial* bearing brass, by adopting the following values for the different parameters (kg/m/sec units).

μ = 0.007 sec/m² (very low value);

V = 4 m/sec (wheel 1 m diameter at 100 km/h);

a = 20 mm (value fixed from experience);

h_0 = 0.003 mm (minimum value for thickness of film also dictated by experience);

m = 5 : value permits avoidance of return currents (resulting from geometrical considerations).

We thus obtain :

$$P_{max} = 0.18 \frac{\mu\ V_a}{h_o^2} = 1.120 \text{ kg/cm}^2 \text{ (15.95 lb/in}^2\text{)}$$

This limiting pressure is capable of sustaining a load in excess of one metric ton per cm² (6.55 tons/in²). Now, a total load of 12 metric tons on a journal 250 mm (10 inches) long (limiting dimension on European railways) corresponds to an average load of only 240 kg/cm² (1.52 tons/in²). It is clear that the margin of safety is wide and that a box of this type will carry any load that does not cause undue yielding of the whitemetal in the bearings.

***

CONCLUSION.

The general considerations and the examples cited above demonstrate in our view that journal bearings provided with superabundant lubrication offer much wider possibilities than is commonly supposed.

We have dealt with this subject at length since its economic aspect is of some importance in view of the relatively low first cost of these bearings.

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(1) Details of the integration are given in the monthly bulletin of the « Société des Ingénieurs et des Industriels ». Bulletin No. 1, 1936, pp. 19 et seq.

[**656** .28 (42]

Colonel Wilson's annual report.

(From The Railway Gazette, December 22, 1950.)

For the third time since the appointment in 1840 of Inspecting Officers of Railways — the first of whom, Lt.-Colonel Sir Frederick Smith, held the title of Inspector General of Railways — a calendar year, 1949, has passed without a passenger being killed in a train accident on the railways of this country, the two previous occasions on which this result was achieved being 1901 and 1908, although there have been other years in which the figure has been extremely small, as in 1925 and 1930, each showing but one fatality under this heading. Lt.-Colonel G. R. S. Wilson, Chief Inspecting Officer of Railways, in his annual report for 1949, characterises that year with good reason as « outstanding ». When the very large number of people carried every year by rail is taken into consideration — and it would take over 13 years day and night to count the number of passenger journeys originating in 1949 — and is compared with the conditions met with in so many other circumstances it is seen that the risks run by the railway traveller are to all intents and purposes practically negligible. Nevertheless public interest is always stirred by the circumstances of any rail mishap, often far more than it is by many other types of accident, partly no doubt from the very fact that to come to harm on the railway is such a rare thing. Of course, this is at times attributable to the good fortune of the circumstances of the moment, as in one particular case in 1949 where a very little difference in the conditions would certainly have resulted in considerable loss of life.

It may be as well to emphasise once again that transfer of the railways to the State has not affected the status of the Inspectorate. The jurisdiction of the Minister of Transport as regards safety matters remains the same, and the duties, responsibilities, and independence of the Inspecting Officers are unaffected by the change. No passenger railway, or part of it, fixed works or electric traction, may be brought into use without the approval of the Minister, and large installations, as well as new methods of signalling, are also included in this rule. These conditions were more particularly defined by the Road and Rail Traffic Act, 1933, in continuance of the requirements laid down in earlier legislation, which continue to be effective. The Minister is further empowered by the Railway Employment (Prevention of Accidents) Act, 1900, to make rules with the object of reducing or removing the dangers and risks incidental to railway service, and such have been made from time to time. In addition, the Railways Act, 1921, empowered the Minister to require or authorise measures of standardisation, but he has no jurisdiction over the construction of rolling stock (except on tube lines), the maintenance of permanent way or signalling equipment, or the qualifications of operating personnel. The reporting of accidents to the Minister, under an order made in 1945, derived from authority conferred by the Act of 1900, previously mentioned, and the Regulation of Railways Act, 1871, requiring notification of all accidents on passenger railways, and such as involve fatality or injury on railway premises, continues as before, as do the formal inquiries carried out by the Inspecting Officers under the Minister's Order, where such appear to be called for by the circumstances of the case.

The report under notice is based on arrangements restored on January 1, 1946, after modified requirements in force dur-

ing hostilities. The table reproduced below, analysing the various causes of train accidents, shows that of the total of 1 176, 373 were collisions and 236 derailments; 386 were cases of running into obstructions (including 137 cases of animals on the line), with 127 fires in trains and 54 miscellaneous accidents. Failure of train crews was responsible for 140 collisions and 49 derailments, while signalmen were answerable for 34 and 14 respectively; 12 collisions were brought about by irregular block working. These 1 176 accidents resulted, as stated, in no fatality to a passenger, but did regrettably cause the deaths of six servants and six other persons. The figures for 1948 were 39 passengers, 14 servants, and 21 other persons.

	Collisions	Derailments	Running into obstructions	Fires in trains	Miscellaneous	Total
1. Failure of train crew (including guard) :						
a) Passing signals at danger	31	13	19	—	—	63
b) Other irregularities or want of care.	109	36	27	—	1	173
2. Failure of signalman :						
a) Irregular block working	12	2	—	—	—	14
b) Other irregularities or want of care.	22	12	5	—	—	39
3. Failure of other operating staff	66	15	63	3	14	161
4. Failure of train crew and/or signalman and/or other operating staff	53	32	39	—	5	129
5. Faulty loading.	1	13	1	—	—	15
6. Technical defects :						
a) Engines	1	13	2	—	2	18
b) Vehicles :						
i. Drawgear	3	18	1	—	—	22
ii. Other items	6	29	1	2	3	41
c) Track or signalling apparatus	2	34	1	—	1	38
7. Other causes :						
a) Snow, landslides, floods	—	2	—	—	—	2
b) Animals on the line	—	—	137	—	—	137
c) Misconduct of the public	38	1	38	16	13	106
d) Miscellaneous	29	16	52	106	15	218
Total	373	236	386	127	54	1 176

Eighteen formal inquiries.

Although no death of a passenger in a train accident fell to be recorded in 1949, it was found necessary to hold 18 formal inquiries into such accidents during the year, the reports on which, generally with an explanatory diagram, have appeared in summarised form in these pages. The leading features of these were as follows :

At Loughborough on January 9, 1949, a freight train was derailed at an engineering site where rails had been removed, and the engine overturned down an embankment. The driver, who was killed, had failed to keep the train under sufficient control on a falling gradient, and there had been failure also on the part of a permanent way inspector to protect the

gap in the correct manner. At Glasgow Cross on January 31, 1949, a train on an underground section of line passed four signals at danger, after seeing the distant at caution, and collided with the preceding one. There was no failure of block working, and the accident was attributable to a serious lapse on the part of an experienced driver, probably due in part to the difficulty of seeing oil lit lamps in ill-ventilated tunnels. An unsatisfactory standard of attention to the lamps was brought to light by the case and an unusual wrong side failure of a light repeater indicator. As an interim measure all signals are being converted to electric lighting and detonator placers installed at all signal boxes.

At Trowse Station, Norwich, on February 3, 1949, occurred a collision caused by a train having to leave the Thorpe terminus against the starting signal, which could not be cleared for it as the engine was on points just ahead unable to be bolted, and then, in consequence of the signalman forgetting to reverse a crossover road, travelling up the down line for 3/4 mile and meeting a standing goods train head on. The signalman was primarily responsible, but the one in the next box should have noticed that the train was on the wrong line, although had any one of the four trainmen been alert they could have averted the accident. At Hensall on the night of March 2, 1949, an engine propelling a van collided with a tank lorry at a crossing, resulting in overturning. There was a good deal of traffic on the road, and the gatekeeper had to exchange bell signals with the signalman to show that the gates were closed before a train movement was permitted. There was conflict of evidence on this matter. A code may not have been sent, or, more probably, was sent and misinterpreted. Signals interlocked with the gates are being provided and the code altered to reduce the possibility of misunderstanding a bell signal. An unusual type of accident occurred at Douglas Park on May 26, 1949, when an express, after receiving a clear distant signal, found the home signal against it and became derailed at loop facing points, which clearly had been operated just as the engine reached them. The signalman, a young man who proved to be unreliable, denied all knowledge of having done this, but there was no doubt that he moved the points or knew who had done so. It was recommended that the pre-war practice of requiring references as to the character of new entrants to the service should be resumed, especially for prospective signalmen.

The fire in an express at Penmanshiel Tunnel on June 23, 1949, also was remarkable in that not only did the flames spring up and engulf two vehicles with extraordinary rapidity, but local circumstances most fortunately combined to enable the fire to be confined to them and casualties to be limited to seven persons injured, although two of these cases were serious. A clear cellulose lacquer had been used on the wooden corridor panels and the Joint Fire Research Organisation of the Department of Scientific and Industrial Research and Fire Officers Committee proved by tests that this was by far the worst material so far examined by them for rapidity of flame spread. This might have been caused by a lighted match, say, or cigarette end. The batch of coaches on which this particular finish had been used were at once taken out of service and it was recommended that no material should be used in future in passenger stock without being subjected to the standard Spread-of-Flame Test, and that fire risks generally should be constantly borne in mind in design and construction, taking advantage of the specialised knowledge of the organisation referred to.

A derailment in Merstham Quarry Cutting on a hot afternoon on June 27, 1949, of a fast electric train was attributed to the ganger not appreciating the danger of disturbing the track in the way he had done, despite strict instructions covering precautions to be taken in hot weather. The

inspector was criticised for failing to ensure the orders were understood and obeyed. It was recommended that the research into strength of different types of ballast, instituted after the Wath derailment of May 8, 1948, should be extended to investigate rail stresses in hot weather, and whether the smoother sleeper-beds produced by modern methods of measured shovel packing affect lateral resistance to any appreciable extent. Another level crossing accident took place at the Hardwicke occupation crossing on June 28, 1949, when a motorcar was run down and the locomotive bogie became derailed. The occupant of the car should have satisfied herself that it was safe to cross, but was encouraged to move by the action of another person opening the gates.

At Chester, in daylight and clear weather on July 4, 1949, the driver of a passenger train, admitted by calling-on arm to an occupied platform, a movement that has to be allowed at this location, failed to exercise sufficient care and struck the train ahead. At London Bridge on July 24, 1949, a driver of a light engine ran by a colour-light signal at red, and met an oncoming electric train at a diamond crossing. Careful consideration of the circumstances and the signalling controls showed that the driver must have been mistaken in thinking he had seen the signal at yellow. Another case of overlooking a signal, in this instance a semaphore, took place at Epsom on July 28, 1949, when an electric train started irregularly from a platform, and although a detonator was exploded, could not be stopped before meeting another crossing its path. The layout precluded the provision of a trap or crossover, but the signal and detonator have been moved back to increase the overrun. At Euston on August 6, 1949, an empty train was routed in error into a platform occupied by one loading to leave. There was no track circuiting, though this has since been provided, and the experienced signalman who made the mistake was working under some pressure of traffic. The general renewal and modernisation of the signalling at this terminus are under consideration again.

On September 30, 1949, occurred a fatality to a fireman at Mangotsfield, whose head was struck by the open door of a banana van, while at Heighington on November 16 there was a collision between a passenger train and part of a goods train left in section, for which a signalman was primarily responsible. Another signalman failed to act as circumstances required, as did two guards on the goods train, and the case generally revealed considerable lack of discipline. Neglect to apply the regulation tests by trainmen led to a train of empties running away on the incline approaching Lime Street Station, Liverpool, on November 19, 1949, and crashing into the buffers there with destructive effects. It was found that the vacuum connection between the first and second coaches had not been made. At Strathmiglo eight days later a train carrying men to some engineering work plunged into a gap in the track and the driver was killed. The permanent way inspector had surprisingly forgotten to protect the work and had not taken steps to see that the driver knew exactly where it was. An accident resembling in most of its features that at Epsom occurred at Littlehampton on November 30, 1949, when an electric train started against the fixed signal and struck almost head on one coming in to another platform. There had been a curious forgetfulness on the part of the signalman in making lever movements intended to permit the outgoing train to leave, and it was suggested that the lie of certain points should be altered to give additional security against such irregular departures. On a dark evening on December 9, 1949, a Continental express approaching Victoria terminus under clear signals collided with a light engine, the driver of which had thought a subsidiary signal was clear for him, but it was not. The engine was pushed slightly foul of another line and an outgoing electric train came in contact with it.

Another accident, by which two servants lost their lives, took place at Oakley Viaduct on October 4, 1949. A goods train, admitted in error under clear signals to a permissively worked « telegraph bell » section, ran into the one ahead, and the engine and several wagons plunged off the structure. A peculiar feature of the case, and one surprising to many, was that this « telegraph bell » working had to be effected by the same bell as served for the block telegraph on the parallel passenger lines. Other mistakes under such working led to block instruments being recommended, and certainly the application of separate bells wherever they did not exist under this system, with provision for actual offering and accepting of trains, not provided for by the old « telegraph bell » rules.

In addition to these accidents many others were dealt with by correspondence by the Inspecting Officers, and in consultation with the railway authorities. The report mentions eleven of these, exhibiting features of some interest, as in the case of a steam-hauled train on the widened lines between Kings Cross and Farringdon Street, where failure of the engine trip was suspected. The locomotive had stopped a few feet past a stop signal, the section ahead being occupied in actual fact, and then the driver accepted the green aspect of a repeater signal ahead. It is now recognised as correct practice to control repeater signals to yellow when a train passes them and the extension of this is under consideration now, with provision of track apparatus to test the trip-cocks of steam trains using London Transport lines. Another special case was a derailment at Bethnal Green where power points in a new signalling installation were moved by a false feed applied accidentally during testing; special precautions against repetition of such a thing are being generally introduced.

« The progressive improvement », states the report, « during the last two years in the total figures of accidents to trains is noteworthy and encouraging, though collisions and derailments again exceeded pre-war averages. Collisions, at 373, were eleven more than in 1948, but there were 40 fewer derailments, and the number of train accidents at level crossings fell from 212 to 165 as compared with an average of 163 for the 15 years 1925-39... Failures of engines and rolling stock, though they have declined progressively since 1946, are still more than pre-war; the rise in the number of broken rails reported during 1949 may have resulted from the more precise instructions issued by the Railway Executive in 1948 to co-ordinate the basis of reporting in all Regions. Other failures of track and structures are less than half those in 1948, a year of exceptional floods. The total number of failures, 4 062, has now declined below pre-war level, and the improvement is due in the main to the marked reduction in coupling failures resulting from the withdrawal of a large number of old and obsolete wagons, mostly from the former private owners' fleet. » Regarding coupling apparatus, the chief liability is still stated to be drawgear weakness, but in goods trains the proportion of failures fell somewhat, reflecting the improved standard of stock in that respect. Again in 1949 no accident resulted from the division of a passenger train.

Level crossings.

It is of interest to note that there are 4 080 public level crossings with gates, 370 without them, and some 22 600 occupation crossings. There are also some footpath crossings. The total number of accidents was 200 compared with 251 in 1948 (1935-39 average 212), of which 165 were train accidents, eight with fatal results, involving collision with gates or vehicles at public road and occupation crossings, as compared with 212 in 1948, and the report gives details of certain cases in addition to those referred to above. One unusual case was that at Bosham, where a gatekeeper at a crossing properly equipped with signals put them to danger and

	Total	Killed				Injured				million train miles	
		Total	Passengers	Railway servants	Other persons	Total	Passengers	Railway servants	Other persons	Killed	Injured
1915-1919	6 122	616	174	341	101	5 506	1 731	3 600	175	1.8	16.5
1920-1924	6 638	407	92	248	67	6 231	2 577	3 518	136	1.1	17.0
1924-1929	7 526	368	91	210	67	7 158	3 733	3 267	158	0.9	18.0
1930-1934	7 440	308	74	183	51	7 132	4 394	2 592	146	0.7	17.0
1935-1939	8 376	338	86	198	54	8 038	5 342	2 576	120	0.8	18.0
1940-1945	1 222 (1)	477	141	254	82	745 (1)	256 (1)	455 (1)	34 (1)	1.2	1.9 (1)
1946	9 529	413	120	236	57	9 116	5 691	3 281	144	1.0	22.6
1947	9 203	409	148	218	43	8 794	5 871	2 785	138	1.1	22.9
1948	8 683	340	87	191	62	8 343	5 554	2 678	111	0.9	20.9
1949	8 651	285	44	188	53	8 366	5 640	2 625	101	0.7	20.2

(1) Serious injuries only.

Accidents, employment and operating statistics

	Class I		Railway servants (March)	Passenger journeys originating (incl. season tickets)			Freight-tonnage originating (excl. free hauled)	Ton-miles (incl. free hauled)	Miles operated				Passenger-miles (estimated)	
	Train accidents	Failures of rolling stock or permanent way		Total	Main line railways	London Transport			Main line railways: Train	Main line railways: Shunting	Main line railways: Other	London Transport: Train	Main lines railways	London Transport
	Number		Thousands	Millions										
1919-1924	1 009	11 153	699 (2)	1 848	—	—	303	17 457	369	121	28	—	—	—
1925-1929	941	9 141	679	1 661	—	—	298	17 562	401	123	29	—	—	—
1930-1934	796	5 772	602	1 612	—	—	270	16 060	416	113	27	—	—	—
1935-1939 (1)	745	4 149	592	1 733 (3)	1 255 (3)	478 (3)	281	17 230 (3)	412	115	29	32	18 993 (4)	2 297 (4)
1940-1945 (1)	387	160	604	1 661	1 210	451	288	23 844 (5)	356	124	37	26 (6)	33 191 (7)	2 608 (7)
1946	1 237	5 162	652	1 855	1 266	589	262	20 639	373	116	36	30	29 231	3 029
1947	1 388	4 679	660	1 714	1 140	574	257	20 190	355	113	35	31	23 015	3 095
1948	1 293	4 398	703	1 646	996	650	276	21 502	366	112	41	34	25 093	
1949	1 176	4 062	648 (8)	1 634	993	641	280	21 848	381	109	41	34	24 958	

(1) Having regard to the altered basis under the Modification Order, fewer accidents were reportable and only serious damage is included as from September 1, 1939, to December 31, 1945. The comparison is unchanged as regards traffic, movement and staff employed. — (2) Four years, 1921-1924. — (3) Four years, 1935-1938. — (4) For year ended August, 1939, only. — (5) Estimate for Main Lines — 1942-1945. — (6) Loaded only. — (7) Three years, 1943-1945. — (8) Railways and London Transport Executives' Staff only.

opened the gates to the road in the face of a train approaching at high speed. In another case someone opened the gates without the knowledge of the crossing keeper, who had failed to lock them, and was seriously injured when a train collided with the gates, while in another a foolhardy motorcyclist, though warned on previous occasions, pushed through the wicket and was struck by a train. At the location in question locking of the wickets was not practicable. The total number of casualties was 83 compared with 92 in 1948 (average for 1935-39 was 85), and of the nine which occurred to occupants of road vehicles four were due wholly or primarily to their own misconduct. Says the report : « The risk of accident at a properly equipped and guarded level crossing is negligible compared to other risks of the road. » Commenting generally on the question Colonel Wilson says : « Improvements to safety arrangements at public road crossings are carried out from time to time when investigation shows that these are necessary... At occupation crossings, where with some exceptions protection is confined to field gates opened by road users, safety of rail traffic as well as their own depends primarily on their care and vigilance. The large majority (21 000) of such crossings are still of agricultural field-to-field and farm-to-road type, and are used mainly by persons acquainted with the local conditions, but the risk of serious derailment is no longer negligible with the increasing use of motor vehicles about the farm and countryside, including heavy lorries and tractors. » The growing risks at these locations have caused « the whole difficult question of safety » thereat to be remitted by the Minister of Transport to the British Transport Commission and its report has now been received. Lt.-Colonel Wilson stresses the point that the 1949 figures should not be allowed to produce a false sense of security or « distract attention from the urgent need to improve conditions, at any rate at those crossings where the risks to rail and road traffic are more serious ».

Movement accidents.

The incidence of fatalities in « Movement » type accidents during the past three years has fallen below pre-war level, but comparison with 1948 does not, states the report, suggest that improvement is progressing. « Injuries to passengers show a rising trend, but the great majority represent minor cases and the increase in the numbers reported during the last two years does not necessarily reflect a corresponding increase in the number of minor accidents. » Mishaps to passengers are largely attributable to their own want of care and the only wonder is that they are not infinitely more serious. An accident at Laindon and Pitsea, in which a child was killed, led to stricter definition of the responsibility of drivers to stop when the communication chain is pulled, though in this particular instance it would have made no difference if the train had stopped at once.

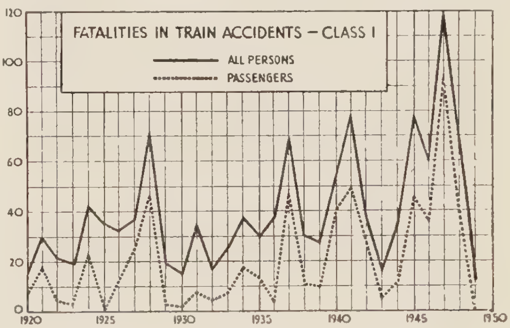
In the case of railway servants, 182 were killed and 2 532 injured in 1949 in this class of accident. The figures for staff working on the line were 53 deaths and 129 injuries, all the fatalities and most of the injuries being caused by engines and trains striking men. The report reviews at some length the various circumstances coming into this category of accidents, such as inadequate protection, lookout man at fault, failure to act correctly after warning, want of individual care or lack of care on the part of others and so on, and remarks that : « Accidents to men through being struck by trains while at work on the permanent way continued to receive close attention, and in every case a formal inquiry was held and the site visited in order that all the circumstances might be taken into consideration with a view to guarding against a recurrence. It is satisfactory to find that, under « protection inadequate », the improvement which was so noticeable in 1948, has been maintained, although the general shortage of manpower must at times have placed the ganger or

man in charge in a difficult position, when deciding whether or not to appoint a look-out man. » We read further that want of individual care and failure to comply with rules, such as that requiring a man to move clear of all tracks unless he can distinctly see that he is in no danger, after warning is given, continues to play a large part in this matter and is naturally difficult to counteract. Colonel Wilson feels that, though collective approach requires special arrangements, « better education in safety matters is the only means whereby these accidents, many of which are inexcusable, may be reduced ». He considers also that it is not enough to leave this to the gangers, whose whole experience is limited often to one length of line and whose own conduct is not always what it might be in this matter. The inspectors are in a better position but, like the gangers, they do not always appreciate that the safety of the men is as much their responsibility as that of the track, and the report records the opinion that « a prize length loses much of its credit if the gang has a bad record of accidents to its members ».

Accidents to staff walking or standing on the line, or when proceeding to and from work, in turn involved many cases of failure to follow well-known safety rules or take the authorised route, laid down expressly for no reason but the staff's safety. In the case of shunting, many regrettable accidents have again to be recorded, attributable to failure to obey rules or take known and reasonable precautions. Reviewing these and certain other movement and non-movement accidents the report says : « Rules, notices, and appliances are provided to guard against dangers whenever possible, but it must rest mainly on the individual to take full advantage of them, though in some types of accident stricter supervision might have a beneficial effect. » It is to be noted that there were no fatalities due to contact with electrical track equipment, but 31 men were injured. In 1948 there were 37 injuries and one fatality.

The report refers to the question, reviewed at length by Sir Alan Mount in the previous year, of trespassers, chiefly children, coming in contact with live rails; in one case access to the line had been obtained by scraping a burrow under a high mesh fencing, which illustrates how great is the difficulty of preventing a determined and adventurous child from achieving its purpose of getting to the line, but « whatever is done, in the way of fencing » — says Colonel Wilson — « the most effective remedy lies in greater recognition by parents and others of their responsibility for preventing trespass on the railway by children in their charge ». The average age of the children concerned in the 27 cases in 1949 was 6 1/2 years; all but one were boys.

The report concludes by reviewing at some length the general features of the year and the progress made amidst many difficulties, in overtaking arrears of maintenance of track, rolling stock, signalling,



Comparison of fatalities from 1920-1949.

and other equipment, and in introducing new and improved methods of operation, as in the case of the re-signalling of the electrified lines between London and Shenfield. Financial stringency is hindering signalling modernisation, but « the unification of management under nationalisation has facilitated the consideration of priorities with a country wide outlook... ». In this way improvements can be concentrated where most needed, but, it is emphasised, the good overall safety record for 1949 in

no way lessens their desirability. Of the 1 176 train accidents 63 were attributed to signals not being obeyed, and it was considered that automatic train control of the warning type might have been effective in 25 cases. The trial of the new design of apparatus, combining the long-tried Western Region cab equipment with track inductor operation, as used on the Southend (*via* Barking) line, is proceeding between New Barnet and Huntingdon and 65 engines are being equipped in connection with it.

« Operation is becoming more efficient » says Colonel Wilson « as the condition of track and rolling stock improves, and, apart from ill fortune, there appears to be no valid reason why the good safety record of 1949 should not be maintained and improved in spite of the factors which are retarding progress in many directions. But whatever is done in the way of providing modern safeguards — and the maximum possible should be done with appropriate priorities according to traffic and other conditions — much will always depend on the men themselves and on their supervision and training. There are still too many accidents which could be avoided by ordinary attention to duty, including the faithful observance of simple safety rules and instructions. This is a question of morale and discipline which affects all grades of the staff and it continues to receive the attention it deserves. Good leadership and encouragement of the right outlook by careful training, tactful supervision, and clarity of verbal and written instructions are essential, but in the railway service where so many men have to work for long periods at a time without supervision, and often alone, the *self* discipline of individuals, which is perhaps its highest form, is of supreme importance to the safety of the public and of themselves. »

[625 .234 (73)]

Radiant heating of railroad cars.

(From the Railway Mechanical and Electrical Engineer, March, 1950.)

A system in which comfort is obtained by heating room surfaces or panels, instead of using convection heating of room air only, is called radiant heating. To understand what advantages can be gained from employing radiant heat in railroad passenger cars, it is important to understand at first what constitutes human comfort and what factors affect the comfort of average normal human beings.

The most important function of any heating system is to control environmental conditions so that the body will lose only the heat that is produced within it — no more and no less. Fortunately, the human body has a wonderful control mechanism which enables it to regulate, to a remarkable extent, the production and dissipation of heat. When the heat dissipation differs from the heat production, a physiological-psychological-thermostat goes into action to adjust digestion of food, flow of blood, action of skin tissues, etc., until the heat produced by the body equals its heat dissipation, so that small variations in temperature, humidity, wind and latitude, do not disturb comfort. However, when environmental conditions cause large differences between heat production and heat dissipation, the capacity of the human thermostat is exceeded and discomfort is noticeable.

The rate at which heat is produced within the body depends partly upon age, sex and size of the person, but activity is the predominant factor. The heat produced within the bodies of normal adults differs under different conditions of activity in a passenger car. For example, the body of a person sleeping produces 290 B.t.u. per hour, which may be compared with 380 B.t.u. per hour when seated at rest and 760 B.t.u. per hour when walking at 2 m.p.h. or equivalent activity.

Heat is dissipated from the body largely by convection, radiation and evaporation, loss by conduction being negligible.

The major factors which determine the heat dissipation by these processes are: 1) Temperature of air within the room — inside air temperature, t_i; 2) temperature of inside surfaces of the room — radiant temperature, t_r; 3) velocity of air — drafts; 4) moisture content of air — humidity.

If the room air temperature is below 70° F., as is usually the case when radiant heat is used, humidity has little effect on heat dissipation from the body. Also, drafts must be kept below 40 ft. per min. to prevent unequal heat loss from different parts of the body. A common procedure is to assume moderate humidity and moderate drafts, and express the relation between the mean ambient temperature and the mean radiant temperature in the form of a simplified approximate equation, called the « Comfort Equation ».

$$t_i + t_r = 140 \quad . \; . \; . \; . \quad [1]$$

The equation indicates that if the ambient temperature is 74° F., the radiant temperature should be 66° F. If the radiant temperature is raised to say 72° F. by heating the surface inside the car, it is possible to maintain comfort even when the ambient temperature is only 68° F.

Advantages of radiant heating of railroad cars.

Modern conventional heating systems for railroad cars are arranged to control ambient temperatures only and no attempt is made to control the radiant temperature. Table I gives inside surface temperatures for different outside temperatures, based upon a coach of average construction having overall coefficients of heat transfer of

0.65, 0.22 and 0.17 B.t.u. per hour per sq. ft. per deg. F. for windows, exposed walls, and ceiling and floor, respectively; and inside air temperature of 74° F.

TABLE I.

Variation in temperature of inside surfaces and inside radiant temperature with outside temperature (Deg. F.)

Outside temperature	Window	Exposed wall	Ceiling and floor	Mean radiant temper.
+40	60.0	69.3	70.4	69.0
0	43.6	63.7	66.1	63.5
—40	27.1	58.1	61.7	57.3

As outside temperature decreases, the temperature of surfaces inside the car decreases so that the radiant temperature, t_r, inside the car is also lowered. Consequently, the decrease in t_r requires a higher ambient temperature, t_a, in order to satisfy the comfort equation. This explains why it is necessary with conventional systems to use thermostats with variable temperature settings.

Conventional heating systems generally use steam radiators which are located along the outside walls near the car floor in an effort to campensate for the large amount of heat that is radiated from passengers to cold windows and cold walls. However, difficulty arises from the fact that the heat radiated from these radiators while steam is flowing remains almost constant because the temperature of the heating fluid (steam) remains practically constant, even though the demand varies. Since the temperature of walls and windows depends upon outside temperature, the amount of heat dissipated from passengers to these surfaces, and hence the demand, varies directly with outside temperature. This condition can be improved by using hot water heating systems (1) * because the desired surface temperature of the hot water radiator can be achieved by controlling the temperature of water.

Stratification of air in layers of different temperature is almost negligible in modern conventional heating systems. But, there is generally a large variation of radiant temperature within the passenger space. Unfortunately, stratification of radiant temperature is seldom given much attention, even though from the standpoint of comfort this is as important as the stratification of air temperature.

Radiant heating has several other inherent advantages. For example: fig. 1, which has been prepared from various sources including reference (2), shows that the range of the comfort zone is increased when the ambient temperature is decreased and the radiant temperature is increased. This increased range of the comfort zone is especially valuable for providing comfort in spite of wide dif-

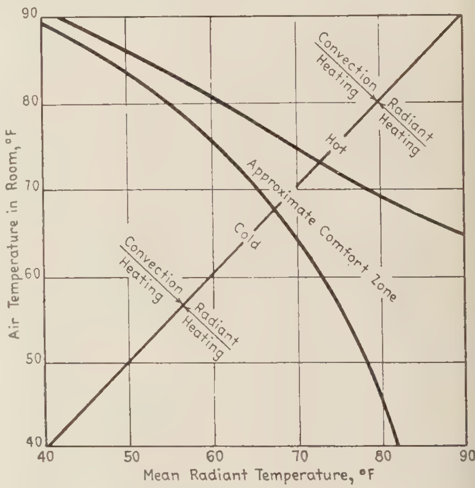


Fig. 1. — Range of comfort at 50 per cent relative humidity and 25 f.p.m. air velocity. — Note that the comfort zone increases as the radiant temperature increases.

* Numbers in parentheses refer to bibliography on page 464.

ferences in passenger requirements due to amount of clothing, activity, personal idiosyncrasies, sex, etc. The use of lower ambient temperatures, which is possible with radiant heating, reduces the shock effect that is felt on leaving or entering the heated room, and it imparts a feeling of freshness and vitality.

Reference (3) states that « the optimum condition for comfort probably lies around an air temperature of 55° F. ». It is mentioned in reference (4), « Ellisworth Huntington collected statistics showing best mental function at 38° to 40° F., whereas 64° F. seemed optimal for physical performance ». Such low temperatures may be impracticable for railroad cars, but these statements indicate that low ambient temperatures properly proportioned to mean radiant temperatures produce pleasant and healthful conditions. The use of low ambient temperature can also reduce the steam comsumption per car and thereby permit an increase in the number of cars per train presently limited by the amount of steam that can be conveyed from locomotive to cars through the train line.

A recapitulation of the foregoing remarks is presented in the following list of advantages of radiant heating of railroad cars compared with the conventional heating systems : Removal of the necessity for high inside air temperatures under cold weather conditions; elimination of cold and extremely hot surfaces; reduction in variation of radiant temperature within the passenger space; elimination of floor heaters and consequent saving in space and cost; wider range of comfort zone and more pleasant and healthful passenger environment.

Location and limiting temperatures of panels.

The most effective location of heating panels is in the exposed walls, especially

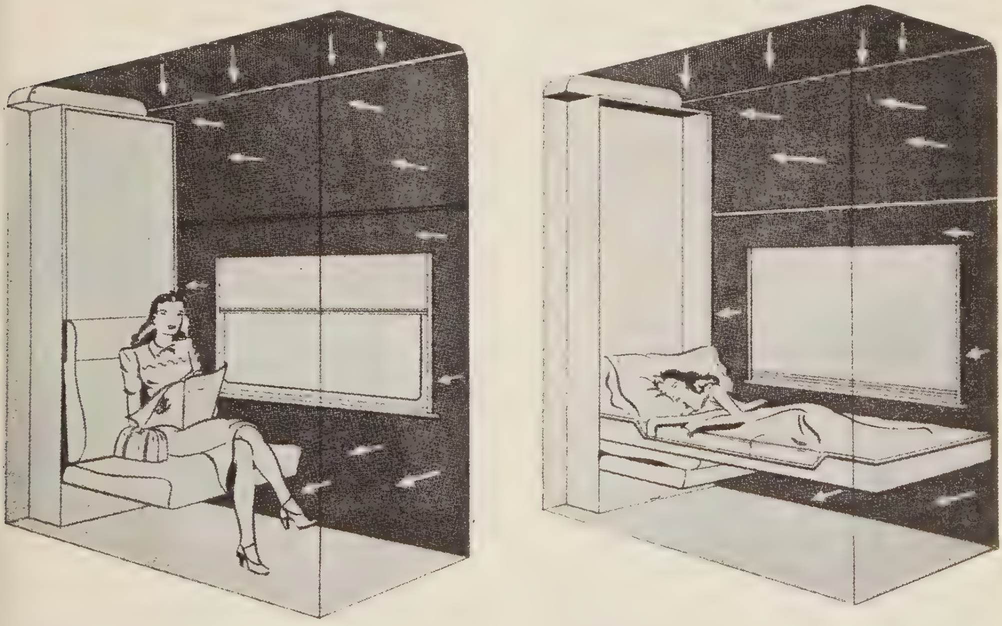


Fig. 2. — Roomette with radiant heat in exposed wall and ceiling. — Note that radiation is received by passenger in sitting position (left) as well as in sleeping position (right).

the area below the window which can be arranged to radiate heat to the legs and feet of the passenger sitting near the window, and the area at the sides of the window which should be proportioned to neutralize the effect of cold window surface, so that heat will be radiated to his shoulders. Cold window surfaces may be entirely eliminated by installation of electrically heated glass, but the cost of installation as well as the operating costs are comparatively high. The temperature of heating panels below and alongside the window should not exceed about 105° F. to avoid being uncomfortably warm to touch.

In order to eliminate radiant heat shadows, it is desirable to locate panels in two surfaces at right angles. The second surface may be the ceiling or the floor, first being the exposed walls. In case of sleeping cars, floor heat is not desirable since the radiation effect from the floor will be almost completely shadowed by the berth. Fig. 2 shows a roomette with panels in the exposed wall and the ceiling, which assures adequate radiant heat to the passenger under all conditions. The average surface temperature of the entire ceiling area should not exceed 85° F. in order to overcome stratification of air in layers of different temperature which is difficult to avoid in rooms having low ceilings (5). Localized ceiling areas, however, may be considerably higher than the recommended 85° F. provided the average surface temperature of the entire ceiling does not exceed this figure.

For coaches, floor heat is desirable since the passengers are close to the floor, in spite of the fact that the percentage of heat given up by radiation is less for the floor than for the ceiling and the fact that heat radiated from the floor is shadowed by chairs. The average surface temperature from the floor should not exceed 80° F. although local temperatures up to 85° F. are not objectionable. Floor temperatures higher than these tend to cause foot discomfort, sweating due to perspiration, swelling and itching. Fig. 3 shows a coach with heated floor, a panel below the window, and a panel in the ceiling; this arrangement would provide equal comfort to all passengers.

For cars having rooms in which heating panels can be located in walls opposite windows, it is highly inadvisable to do so. Such panels will increase the radiant temperature gradient in the room, and waste a considerable amount of heat by radiating to the windows in spite of the fact that glass has good reflectivity and low emissivity for low temperature radiations having long wave-length.

The final decision regarding location of panels must also take into consideration the aspect ratios of the room as well as the locations of openings for air supply, air exhaust, and recirculated air, in order that local drafts and stratification of air temperature may be kept at a minimum. For instance, when using ceiling panels, if the air supply inlets are located in the ceiling and have fairly high discharge velocity, the sweeping action of air over the ceiling sur-

Fig. 3. — Coach with radiant heat in floor, exposed wall, and ceiling. — Passengers in aisle seats and window seats can be equally comfortable.

face may result in objectionably-high air temperature near the ceiling. With these conditions, the average surface temperature of the ceiling may have to be limited to 75° F., instead of the recommended 85° F. average. Consideration should also be given to the possibility of using the same panels for radiant cooling during warm weather.

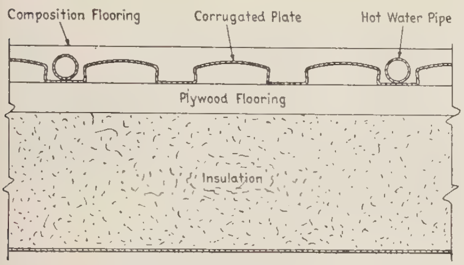


Fig. 4. — Vertical section through floor showing a method of installing hot water pipes.

Medium of heating.

Hot water, steam, hot air, or electricity may be used as the heating medium. There are two major advantages of using hot water instead of steam for radiant heating. First, hot water panels have practically uniform surface temperatures over the entire heating area, whereas, steam panels are generally much warmer on the steam side than on the condensate side. Second, surface temperature of hot water panels can be controlled by varying the water temperature in accordance with the load requirements, whereas an off-on control must be used for steam panels because pressure and temperature of the steam supply remains practically constant regardless of the heating demand. The last disadvantage may be eliminated by using steam under vacuum, which, however, creates several other undesirable features when applied to railroad cars. The principal disadvantage of hot water systems is the increment in the weight of the car due to the weight of water in the system.

An example of water-heated floor panels as applied to several railroad cars built in Mexico is given in reference (6).

Hot air has been satisfactorily used for radiant heating of buildings (7, 8 and 9). Its application to passenger cars is especially attractive, since the same system may also be used for panel cooling with practically no changes in the existing cooling unit and only minor changes in the duct system. Several different designs of air flow are possible. For instance, air ducts may be built into ceilings and exposed walls and arranged so that hot air will flow along the ceiling and the exposed walls and be discharged into the car near the floor through properly designed outlets; or endless air duct system may be built into ceilings, exposed walls and floors, and arranged so that hot air will be circulated continuously through the duct system without being discharged into the car. In the latter type of heating or cooling system, it is necessary to supply air required for ventilation by means of an entirely separate system of fans, ducts, heat exchangers, etc. A third method of air flow can be accomplished by means of air ducts built into the floors and exposed walls, and arranged so that the hot air entering the floor duct will travel outwardly along the floor and upwardly through the exposed walls and be discharged into the car through properly designed outlets located near the ceiling. The window may be warmed by providing perforations or slots in or along the window sill whereby some warm air from the side wall duct can be made to flow over the glass.

For railroads using overhead electric power, heating the panels electrically is the most direct method. However, for steam or diesel-driven trains, the available axle generator capacity is only sufficient to warm the walls of the windows and thereby augment the heat supplied by the steam heating systems. Furthermore, when axle generators are used, electric heating is inefficient since it involves conversion of heat energy into work (a process having

low efficiency) in the locomotive, work into electric energy in the generator, and finally the conversion of electric energy into heat.

Some special problems.

While solutions of most of the problems related to design of radiant heating systems for railroad cars may be obtained by referring to publications devoted to the theory and practice of radiant heating as applied to buildings, there are several problems that are peculiar to railroad cars. These problems may be solved by analytical and experimental methods based upon fundamental laws of heat transfer and well-known principles of engineering. For instance, when the heating medium is hot air circulated through ducts, it is important to know the variation of air temperature in the duct since the air temperature determines the panel temperature. A theoretical analysis of this problem points out a remarkable fact; that is, the temperature drop of air in a duct depends upon the c.f.m. per ft. width of the duct, and not upon the velocity of the total c.f.m. in the duct. The air velocity is unimportant as long as it is kept within the noise limit. Another special problem arises when spacing of hot water pipes is considered. The pipes of the hot water radiant heating systems in buildings are generally imbedded in concrete at a distance of 1 to 6 in. from the heating surface. This helps in obtaining fairly uniform surface temperatures. In railroad cars the pipes in the floor have to be placed at a distance of about 1/2 to 1 in. from the inside surface, as shown in fig. 4. Also, the heat loss through the floor is much greater in railroad cars than in buildings. Therefore, the design data commonly used for finding suitable spacing of pipes in buildings cannot be directly applied to railroad cars. More data must be developed if local hot spots are to be avoided.

In radiant heating, it is important that the heating arrangement be well engineered. The history of radiant heating of buildings is full of cases where application of rough rules of thumb led to disappointing results. If similar disappointments are to be avoided in railroad cars, it is necessary that the basic problems be attacked first by analytical and experimental methods before the development of a satisfactory radiant heating system for railroad passenger cars can be expected.

ACKNOWLEDGMENT.

To W. J. MEYER, engineer of general development*, for assistance in preparation of the article; to O. C. MAIER*, J. E. CANDLIN, Jr.*, and H. F. PETERSON*, for helpful criticism.

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* Research and Development Department, Pullman-Standard Car Manufacturing Company, Hammond, Ind.

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OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association.

Meeting of the Permanent Commission, held in London, on March 5th, 1951.

At the invitation of the British Railways, the Permanent Commission of the International Railway Congress Association met at the Railway Executive headquarters in London, on March 5th, 1951.

***

Mr. DELORY, *President*, opened the meeting by thanking the British Government and Railway authorities for the great welcome extended to the members of the Permanent Commission, and expressed his particular gratitude to LORD HURCOMB, *Chairman of the British Transport Commission*, through whom the invitation was issued.

THE PRESIDENT then made a start on the aggenda and asked the Meeting to approve the minutes of the meetings held in Rome on September 29th and October 4th, 1950.

***

MR. GHILAIN, *Vice-President and General Secretary*, advised the Meeting of alterations in the composition of the Permanent Commission since its last meeting, as well as the steps taken to fill vacancies.

The Meeting then nominated the following as members of the Permanent Commission :

M. Xavier REMY, Directeur des Chemins de fer Fribourgeois et Président de l'Union d'Entreprises suisses de Transport, in place of M. MARGUERAT, resigned;

Mr. Halvdan E. STOKKE, General Manager of the Norwegian State Railways, to replace the late Mr. Egil SUNDT;

Dr. M. SCHANTL, General Secretary of the Austrian Federal Railways, in place of Dr. Friedrich MAYER, who has retired;

H.E. Mohamed EL WAKIL, Minister of Communications in Egypt, in place of H. E. ALY ZAKI EL ORABY Pacha;

Mr. John ELLIOT, Chairman of the Railway Executive (British Railways), in place of Sir Eustace MISSENDEN, who has retired;

Lt. Col. G. R. S. WILSON, Chief Inspecting Officer of Railways (Great Britain) in place of Sir Alan MOUNT, who has retired;

Dr. Eng. Filippo FAZIO, Chef du Service de la voie des Chemins de fer de l'Etat italien, nominated to take the place of Mr. G. DI RAIMONDO, who has become a life member of the Permanent Commission as former President of a Session;

Mr. Vito PERRONE, Ingénieur, Inspecteur Général Supérieur de la Motorisation Civile et des Transports concédés (Italie),

to replace Mr. Ugo VALLECCHI, Engineer who has retired;

Mr. TUJA, General Secretary of the International Railway Union, succeeding Mr. G. PADER, who has retired.

— *The complete list of the members of the Permanent Commission is given in the Appendix.*

***

Mr. GHILAIN, *General Secretary*, then gave the Meeting details of the provisional programme for the Enlarged Meeting of the Permanent Commission in Stockholm in 1952, at the suggestion of Mr. E. G. J. UPMARK, General Manager of the Swedish State Railways. This meeting will take place in the first fortnight in June 1952 and will consist of several technical meetings at which three questions selected from those put forward by the member Administrations will be discussed.

The Meeting selected the three following questions and choose the countries, who will be asked to nominate reporters for these questions.

SECTION I.

Way and Works.

Question 1 :

A. — What are the new safety measures taken for level crossing of railway tracks by the Road in respect of the density, high tonnage and speed of the road traffic?

In particular automatic signalling and closing of level crossings without keepers, worked by the trains themselves.

Technical and statistical investigation in order to ascertain the relative safety of :

1° level crossings with keepers, with the different devices to announce the arrival of the trains to the keepers;

2° level crossings without keepers :

a) without any self-acting device announcing the arrival of trains;

b) with automatic signalling for the road-users;

c) with automatic signalling completed by half- or entire gates.

B. — Level crossing of railway tracks by road with a railway (suburban or urban) running alongside.

Reporting countries :

French speaking : *France.*
English speaking : *Great Britain.*

SECTION III.

Working.

Question 2 :

What are the quickest and most economical means to carry out door to door service for railway transports?

What are the best conditions of use of containers for small miscellaneous traffic (dimensions of the containers, conditions of ownership, tariffs).

What are the packing types to be recommended?

Reporting countries :

French speaking : *Switzerland.*
English speaking : *Netherlands.*

SECTION IV.

General.

Question 3 :

Economic aspects of ;

a) discontinuing service on old railway lines;

b) construction of new railway lines; with regard to the possibility of handling transport with other means.

Reporting countries :

French speaking : *Belgium.*
English speaking : *Sweden.*

— *The list of questions and names of the reporters will be published very shortly.*

The Meeting agreed to a suggestion put forward by the GENERAL SECRETARY regarding the size of delegations to the Meeting. Members of the Permanent Commission will be allowed to take one or two members of the higher grades of staff of their Department with them, as on the occasion of the Enlarged Meeting at Lisbon.

***

Mr. UPMARK, *General Manager of the Swedish State Railways*, made a few comments inspired by the works of the Rome Congress, concerning on the one hand the preparation of the Reports, and on the other the procedure to be followed during the discussions by the Sections.

After an exchange of opinions between the PRESIDENT, Mr. GHILAIN and Mr. UPMARK, and at the suggestion of Mr. DEN HOLLANDER, *Chairman of the Netherlands Railways*, it was decided to set up a Sub-Committee consisting of the Executive Committee of the Association together with Messrs UPMARK and DEN HOLLANDER, which would be responsible for examining these questions. The report issued by this Sub-Committee will be put before the Permanent Commission at the Stockholm meeting.

***

Mr. GHILAIN, *General Secretary*, advised the Meeting that the enquiry prescribed by Article 4 of the Rules and Regulations concerning the request of the Kingdom of Cambodia had obtained the necessary number of favourable replies. The list of countries appended to the Rules and Regulations will therefore be completed.

***

The financial accounts for the year 1950 were approved by the Meeting, as well as the budget for 1951. In order to meet the expected financial demands, especially for the organisation of the Enlarged Meeting at Stockholm in 1952, and the next Congress to be arranged in 1954, the Meeting decided to increase the variable part of the contribution for 1951 to 0.23 Gold-franc and to propose rates of 0.25, 0.26 and 0.28 Gold-franc for the years 1952, 1953 and 1954 respectively. It will be remembered that the maximum fixed in the Rules and Regulations can be as much as one third of the Gold-franc.

***

Account was taken of the changes in membership which have occurred since the Meeting of the 4th October 1950.

The International Railway Congress Association now includes 35 Governments, 8 Organisations and 105 Administrations, with a total development of approximately 450 000 km (280 000 miles).

***

An examination of certain points concerning the activities of the Association since the last meeting concluded the meeting.

The General Secretary, P. GHILAIN. *The President*, F. H. DELORY.

List of Members of the Permanent Commission

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(5th MARCH 1951)

President :

F. H. **Delory** (3), directeur général de la Société Nationale des Chemins de fer belges; 19, rue du Beau-Site, Bruxelles.

Vice-presidents :

Goursat (1), directeur de la Région du Nord de la Société Nationale des Chemins de fer français; 18, rue de Dunkerque, Paris (X^{e});

P. **Ghilain** (2), directeur du Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges; 19, rue du Beau-Site, Bruxelles.

Members of the Executive Committee :

Dorges (3), inspecteur général des Ponts et Chaussées, secrétaire général aux Travaux publics, directeur général des Chemins de fer et des Transports au Ministère des Travaux publics et des Transports; 244, boulevard Saint-Germain, Paris;

Lord **Hurcomb** (1), Chairman of the British Transport Commission; 55, Broadway, London, S. W. 1;

Sir Gilmour **Jenkins** (2), Secretary to Minister of Transport (Great-Britain); Berkeley Square House, Berkeley Square, London, W. 1.

Ex-presidents of session, members ex-officio :

Ing. G. **di Raimondo,** directeur général des Chemins de fer de l'Etat italien; Rome;

S. E. Ibrahim Fahmy **Kerim** Pacha; Le Caire;

D^{r} W. **Meile,** ancien président de la Direction générale des Chemins de fer fédéraux suisses; Brügglerweg, 11, Berne.

Members :

S. E. Abdel Rahman el Sayed **Ammar** Bey (3), sous-secrétaire d'Etat au Ministère des Communications d'Egypte; Le Caire;

Armand (3), directeur général de la Société Nationale des Chemins de fer français; 88, rue St-Lazare, Paris (IX^{e});

F. Ch. **Badhwar** (3), Member, Railway Board, Ministry of Railways, Government of India; New Delhi;

V. M. **Barrington-Ward** (2), member of the Railway Executive (British Railways); 222, Marylebone Road, London, N. W. 1.;

M. **Beevor** (1), Chief secretary and legal adviser to the British Transport Commission; 55, Broadway, London, S. W. 1;

Besnard (2), chef de service adjoint au directeur général des Chemins de fer et des Transports, Ministère des Travaux publics et des Transports; 244, boulevard Saint-Germain, Paris;

David **Blee** (3), member of the Railway Executive (British Railways); 222, Marylebone Road, London, N. W. 1;

J. **Bouciqué** (3), directeur du Service de la Voie de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles;

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R. **Claudon** (3), inspecteur général des Ponts et Chaussées, vice-président du Conseil d'administration de la Société Nationale des Chemins de fer français; 88, rue Saint-Lazare, Paris (IX^{e});

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D^{r} R. **Cottier** (1), directeur de l'Office Central des Transports Internationaux par Chemins de fer; Berne;

T. C. **Courtney** (3), Chairman of the Coras Iompair Eireann, Kingsbridge Station, Dublin;

(1) Retires at the 16th session.
(2) Retires at the 17th session.
(3) Retires at the 18th session.

Csanadi (1), Directeur Général des Chemins de fer de l'Etat hongrois; Budapest;

Dr Ing. A. **Cuttica** (3), chef du Service du Matériel et de la Traction des Chemins de fer de l'Etat italien; Florence;

Dargeou (3), directeur du Service central du Mouvement de la Société Nationale des Chemins de fer français; 8, rue de Londres, Paris, (IXe);

J. **de Aguinaga** (2), directeur général adjoint du Réseau National des Chemins de fer espagnols; Madrid;

F. H. **Delory** (already named);

F. Q. **den Hollander** (1), président des Chemins de fer néerlandais; S. A.; Utrecht;

Ing. V. **Dešic** (2), professeur à la Faculté Technique de Belgrade, Conseiller permanent du Ministère des Chemins de fer de la République fédérative populaire yougoslave; Belgrade;

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Ing. G. **di Raimondo** (already named);

Dorges (already named).;

S. E. Mohamed **El Wakil** (1), Ministre des Communications d'Egypte; Le Caire;

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P. **Ghilain** (already named);

Goursat (already named);

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Lord **Hurcomb** (already named);

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Sir Gilmour **Jenkins** (already named);

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A. **Kriz** (3), ingénieur, conseiller supérieur de Section au Ministère des Communications de la République tchécoslovaque; Prague;

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(2) Retires at the 17th session.
(3) Retires at the 18th session.

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Dr Ing. V. **Perrone** (1), inspecteur général supérieur de la Motorisation Civile et des Transports concédés; Rome;

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H. E. **Stokke** (2), directeur général des Chemins de fer de l'Etat norvégien; Oslo;

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H. **van Galen Last** (3), directeur général des Transports au Ministère des Transports et du Waterstaat; La Haye;

F. Perez **Villamil** (2), sous-directeur général du Réseau National des Chemins de fer espagnols; Madrid;

Wagner (1), ingénieur en chef au Ministère des Communications de Pologne; Varsovie;

S. E. le Dr Sayed Abdel **Wahed** Bey (3), directeur général à l'Administration des Chemins de fer, Télégraphes et Téléphones de l'Etat égyptien; Le Caire;

R. B. **White** (1), president, Baltimore & Ohio Railroad Company; Baltimore, Md;

Lt.-Col. G. R. S. **Wilson** (2), chief inspecting officer of Railways, Ministry of Transport; Berkeley Square House, Berkeley Square, London, W. 1;

N... (2), China.
N... (2), Spain.
N... (1), Portugal.
N... (2) Rumania.
N... (2) Switzerland.

Honorary members : R. **da Costa Couvreur**, ancien président du Conseil supérieur des Travaux publics au Ministère des Travaux publics et des Communications du Portugal; Alameda das Linhas de Torres, 145, Lisbonne;

U. **Lamalle**, directeur général honoraire de la Société Nationale des Chemins de fer belges, professeur de cours de chemins de fer à l'Université de Louvain; 175, avenue Winston Churchill, Uccle-Bruxelles.

(1) Retires at the 16th session.
(2) Retires at the 17th session.
(3) Retires at the 18th session.

SECRETARY'S OFFICE : **19, rue du Beau Site, Brussels.**

General Secretary : **P. Ghilain** (already named).

NEW BOOKS AND PUBLICATIONS.

[**385** (494)]

L'Informateur du Rail. — A brochure published under the auspices of the Swiss Federal Railways. — No. 2, Summer, 1950 (5 1/2 × 8 1/4 in.), about 50 pages, with numerous illustrations. Orell Füssli, publishers, Zürich. (Price : 0.80 Sw. fr.)

L'Informateur du Rail, which is designed to inform the public on the work and administration of the Swiss Federal Railways, a State undertaking, was first published in the autumn of 1948.

Since then the technical, economic and financial aspects of railway problems have been somewhat altered. The management reports and annual statistics have been affected by these changes but it nervertheless seems not inappropriate to illustrate and comment upon them again in a brochure of this kind.

L'Informateur du Rail is, in effect, intended solely to inform the ordinary citizen, who may not be a specialist, of the many problems which a railway undertaking must settle in its purpose of serving the public.

It is published in French, German, Italian and English and is on sale at most bookstalls and railway booking offices of the Swiss Transport undertakings.

[**621** .33]

KOSTER (Ir. J. P.), Electrical Engineer, attached to the Electric Department of the Netherlands Railways Rolling Stock, Shops and Electrification. — **Gelijkstroomtractie op Hoofdspoorwegen** *(Direct current electric traction on main line railways).* — One volume (6 3/4 × 9 1/2 in.) of 588 pages with 274 figures and IX plates. — 1949, Haarlem, Antwerpen, Uitgeverij J. H. Gottmer.

Statistics relating to the development of electric traction show that the Netherlands Railways had 130 km (81 miles) of electrified lines by 1927, representing 3.8 % of the system. Consequently their experience in this matter is already long. At that time, they held the fourth place amongst the European systems. In 1947, they were still fourth with 570 km (354 miles) of electrified line, i.e. 16.7 % of the system. In addition the programme under preparation covered a further 965 km (597 miles) of line.

Other statistics show that direct current is the most widely used, at least if the number of countries using it is taken into account.

Without overlooking the qualities of the single phase system, the author has limited his subject to direct current traction on main line railways. The applications of electrotechnique to traction have developed to such an extent that it is no longer possible to cover the whole field in a book of standard size. Having limited his subject in this way, owing to his considerable experience, the author has been able to deal with it under its various aspects in a very thorough manner.

The study is divided into two main parts, on the one hand the installations intended to supply the current to the motors, and on the other the rolling stock including the locomotives and motor coaches.

An introduction makes a comparison

between electric traction and other methods of traction, gives the history of the development of electric traction and compares the direct current system with other systems.

The latter are considered in the order in which they are now favoured, starting with the most popular. The three phase system, in spite of the very successful use made of it in Italy, is handicapped by the double contact wire required and the special characteristics of the motors. Having gone into every point, the author gives the chief advantage of direct current as the characteristics of the series motor which is the traction motor per excellence. He also discusses the question of the voltage of the supply. Summing up, he explains the principal circumstances which in his opinion determine the choice of current and voltage.

The installations for supplying the current to the locomotives start with the main high tension supply lines and include in particular the substations and overhead lines. Much space is devoted to the equipment upon which the safety of the supply depends.

In transforming the current, rotary machines have been superseded by mercury vapour rectifiers. Very detailed descriptions are given of the latter, together with a study of the working of an automatic substation. The voltage transformers require special arrangements on account of the special characteristics of the rectifiers to which they supply current.

Overhead lines are tributaries of electricity and of mechanics which play their part in determining the arrangement to be adopted. Complete calculations are given both as regards the load and voltage drops in the catenaries and the fatigue of the materials used for the lines and their supports.

The third rail method is given the attention it deserves. The return of the current through the rails gives rise to losses of current and to voltage drops which must be realised sanely and met by the use of devices which are still capable of improvement.

Towards 1936, the struggle between the different types of drive ended in the victory of the individual axle drive method. The author deals only with the latter, and gives the most recent and successful applications. Before this, he went into the mechanical and electrical requirements of the motors, with all the possibilities of coupling intended to satisfy the different running conditions. The mechanical details of the locomotives together with a description of the electrical equipment ends the chapter dealing with the most important traction unit.

Another chapter describes the electrical arrangement of rail motor coaches, used to a large extent for passenger services.

From the point of view of the electric braking, single phase and direct current motors are very different, and this matter is discussed taking into account the nature of the current supply and the transformation equipment.

In the chapter devoted to lighting, the author describes two recent methods, the main principle of which is a regulator to assure a sufficiently constant voltage for the bulbs and obtain a satisfactory rate of charging of the auxiliary battery. In the case of the heating of coaches, the arrangements analysed use electric power exclusively and cover both stock used on electrified lines and coaches which sometimes run over such lines. In this case heating by hot air is an interesting application.

The fourth part of the book deals with the layout of fixed installations and motor vehicles, a study based on a given train service.

There is a supplement of several chapters dealing with questions relating to the phenomena encountered with mercury vapour electronic equipment. These are entitled : Some considerations on the physical functioning of mercury vapour rectifiers; Return currents, cause and remedies; Monoanodial rectifiers (ignitrons and excitrons); Change of direction. In the latter case, it is question of making equipment, then known as direction changers, play the opposite part

to that normally asked of them, so as to supply the system with electric current produced by regenerative braking.

In this brief summary, we have had to pass by many interesting points, merely pointing out the main subjects covered. But this no doubt will suffice to show the merits of the work, which is worth the attention of all those for whom the author wrote it, i.e. electrotechnical students, those whose profession or duties lead them to deal with electric traction, and those who are attracted by this extraordinary wide application of electricity and wish to increase their knowledge of the theoretical foundation and realisations.

A copious bibliography at the end of each chapter of the work facilitates research.

E. M.

[**621** .134.4]

KALLA-BISHOP (P. M.). — **Tandem compound locomotives.** A historical review. — One volume (5 1/2 × 8 1/4 in.) of 70 pages with figures and plates. — 1949, London, Kalla-Bishop Books, 4 Temple Fortune Court, N.W. 11. (Price : 5/6d.)

This first half of the twentieth century has seen both the perfecting of the steam locomotive and the birth of its competitor the electric locomotive. The increase in the steam pressure and the application of superheating were the principal means by which an improved efficiency was obtained. To these factors must be added a more thorough study of the draught and the gas and steam circuits.

If the thermic cycle alone is considered double expansion was the great discovery of the last century. Originating from France where it remained in favour for a long time, it was stabilised in the form of the four cylinder mechanism, two high pressure on the outside and two low pressure on the inside of the frame. Elsewhere, for example in England, the three cylinder combination had a certain success.

These two solutions however did not meet the requirements of those who looked askance at the complication involved and the additional maintenance of the interior mechanism, nor such railways as those of the U. S. A. where for the same reasons and others the crank axle was unknown. This was the reason for the rather surprising extension of the tandem compound locomotive.

In this case the four cylinders are all sited on the outside, the two on the same side, one in front of the other, which is the true tandem arrangement, or else one above the other as in the Vauclain method. One of the attractions of the tandem construction was its closer approximation to the orthodox two cylinder engine, as well as the fact that it avoided the problem since solved of the equal distribution of the work between the two cylinders.

This book describes in chronological order all the tandems designed and built. The work they carried out during what often proved to be a very full life, and their final end are part of the history of this special technique. They were all the result of the best railway practice of the time, and as is natural, it is above all the mechanism and the distribution and starting gear with which the author is concerned. The drawings which accompany the text show very clearly the cylinder and valve gear arrangement adopted, which are often rather complicated. The outline drawings and photogravures show the whole of the mechanism very clearly.

The steam locomotive has a glorious past behind it. Its present position which will enable it to play a leading role for many years to come is the fruit of the patient work of several generations of railway

engineers. It is not the least of the author's merits that he has contrived to give life to his study by linking up his technical considerations with the names of those who played a preponderant part in the original inventions.

In the final chapter the author puts forward certain remarks upon the compound locomotive in general. Then returning to the tandem method, he reports and discusses the objections that can be raised against it. As regards the first which is based on the high weight of the equipment in alternating motion, it is significant to see that the tandems are intended preferably for moderate speeds.

It is nonetheless true, however, that they have done some remarkable work. For example the 2-8-0's built to the designs of John Player for the Atchinson, Topeka and Santa Fe Railway, where they run on a line with a steady rising gradient of 1.33 %, crossing the Raton pass on an approach gradient of 3.5 %. The locomotives which obtained the power record for this railway between 1901 and 1903 were built on the tandem principle. A historical fact is brought out here. The 2-10-0 used as bankers showed a tendency to derail on the way down on curves, so it was decided to equip them with a rear carrying axle, which gave the 2-10-2 wheel arrangement known as the « Santa Fe » ever since.

E. M.

First European Machine Tool Exhibition.

(Paris : from the 1st to the 10th September 1951.)

When finally set up in Paris in October 1950, the *European Committee for the Cooperation of the Machine Tool Industries* decided to organise technical and specialist International Machine Tool Exhibitions.

The unanimous choice of all the countries represented fell upon Paris as the place at which the *first European Machine Tool Exhibition* should be held in 1951.

This exhibition will be open between the 1st and 10th September 1951 in the buildings of the « Foire de Paris » at the Porte de Versailles.

It will be reserved for machine tool makers, who are members of the Committee for the Cooperation of the Machine Tool Industry, together with other countries who have been invited to join.

The General Commissariat of the Exhibition has been placed in the hands of the « Syndicat des Constructeurs Français de Machines-Outils », 2*bis,* rue de la Baume, Paris, who will deal with questions of organisation for visitors (journeys, hotels, etc.).

In view of the interest and extent of this exhibition, which is also of interest to the railways, we thought it advisable to call the attention of readers thereto.

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P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(JULY 1951)

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ROSEMEIER (H.). — Der **Gleismesswagen** der
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TROTHOTTE (P.). — **Entlüftung und Rauchabfüh-**
g in Lokomotivhallen. (2 500 Wörter & Abb.)

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AHLING (B.). — Über die **Prüfung der Brücken,**
len und Dächer. (10 000 Wörter & Abb.)

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NELL (H.). — **Trassieren** einmal anders ! (5 000
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EIBBRAND (K.). — Die **Baukosten von Schiene**
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WITTE (C.). — **Schienenbefestigung auf Stahlbeton-**
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GRANDRATH (F.). — Erhöhung der **Betriebssicherheit auf Nebenbahnen.** (1 000 Wörter & Abb.)

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The Locomotive, March 15, p. 34.
1750 B.H.P. Diesel-electric locomotive. (1 600 words & fig.)

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The Locomotive, April 14, p. 61.
HAUT (F. J. G.). — **French electric locomotiv**
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ilway Gazette, July 7, p. 15.
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ilway Gazette, July 14, p. 40.
More Swiss lightweight electric locomotives. (400 rds & fig.)

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Coaching stock weight and locomotive power. (1 600 rds, tables & fig.)

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ilway Gazette, July 28, p. 98.
ALLEN (C. J.). — **High speeds in Switzerland.** (1 000 rds & fig.)

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Railway Gazette, August 4, p. 123.
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1950 **621** .33 (44)
Railway Gazette, August 11, p. 152.
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Railway Gazette, August 11, p. 155.
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Railway Gazette, August 25, p. 219.
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Infra red lamps in the Diesel shop. (1 400 words & fig.)

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Lima-Hamilton switcher. (2 000 words & fig.)

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MAY (H. E.). — **Reducing smoke in firing locomotives.** (2 000 words & fig.)

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Cool-down system of boiler washing. (660 words & fig.)

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Railway Mechanical Engineer, October, p. 543.
Budd rail Diesel car. (2 000 words & fig.)

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O'CONNOR (C.). — **Modernizing the steam locomotive.** (3 000 words.)

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Joint session hears about fuel. (1 200 words.)

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1951 625 .251

Ferrocarriles y Tranvias, enero, p. 12.

de GOYENA (J. M. P.). — **Frenado decelerometrico.** (1 000 palabras & fig.)

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RUIZ DEL CAMPO (F.). — La **velocidad** de los **trenes** y el relievo topográfico. (2 000 palabras & fig.)

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GIBERT Y SALINAS (A.). — **Peligros de la promidad entre las instalaciones de tracción eléctrica y de señales y comunicaciones eléctricas.** (12 000 palab & fig.)

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VASCO RAMALHO (R.). — **Construcción de coc ferroviarios.** (5 500 palabras, cuadros & fig.)

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VEZZANI (F.). — **Entità e costo degli autotrasporti** ll'anno 1950. (15 000 parole & tabelle.)

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De Nederlandsche Spoorwegen in 1950. (2 500 woorden.)

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BURGER (H.). — Regeling van en **contrôle op de loop** · **treinen** bij de Nederlandsche Spoorwegen. (1 000 vorden.)

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oor- en Tramwegen, Nr 1, 11 Januari, p. 5.
VAN DORSSER KEUS (J. A.). — **Waarom electri-eren de Zweedse Staatsspoorwegen**? (4 000 woorden fig.)

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oor- en Tramwegen, Nr 3, 8 Februari, p. 33.
KNOOK (A. L.). — **Particuliere sporen.** (4 500 vorden.)

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oor- en Tramwegen, Nr 4, 22 Februari, p. 49; Nr 5, 8 Maart, p. 74.
VAN BILDERBEEK (B.). — Enige indrukken van 1 bezoek aan de **Britse Spoorwegen.** (5 000 woorden fig.)

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GUERRA MAIO. — O « **Talgo** ». (1 500 palavras.)

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LOPEZ GALVÃO (A.). — **Caminho de ferro Cabo-Cairo.** (6 000 palavras & mapa.)

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LOPEZ GALVÃO (A.). — **O porto e o caminho de ferro da Beira.** (3 000 palavras & fig.)

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LOPEZ GALVÃO (A.). — As Rhodesias e a sua **rede ferroviária.** (4 000 palavras & mapa.)

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GALRINHO PERNES (O.). — **Désgaste ondulatório de carris.** (1 000 palavras.)

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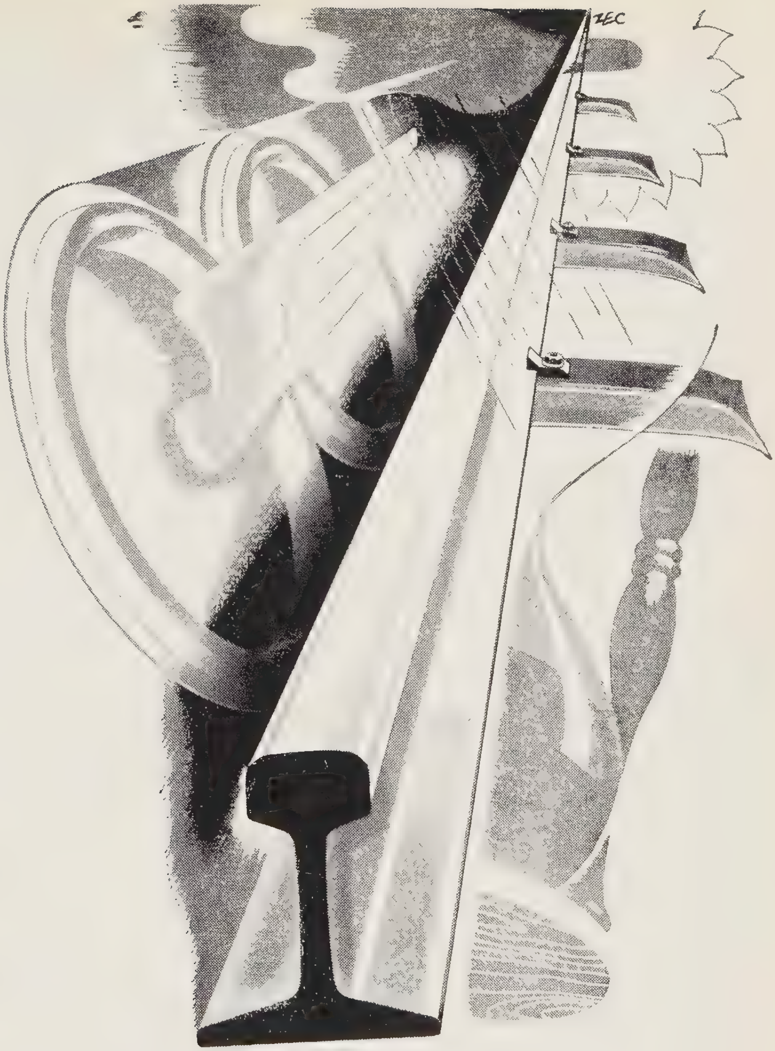
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